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GEOLOGY AND ECONOMICS[1]

DURING the century which has just closed, the various branches of natural science, botany, zoology, geology and their relatives, having earlier completed their childhood, attained to the well-rounded development of maturity. Their broad truths were given clear expression; they were widely apprehended; and they became the foundations of various inventions and applications of far-reaching influence upon human welfare. Geology, although closely bound up with agriculture, has, nevertheless, been especially concerned with mining. And justly so, because its contributions to the art of mining have been no more than a filial return, since mining as practised in the middle ages was the parent of geology. Until recent years geology's services to the industry have been chiefly rendered in spreading sound and reasonable ideas regarding the nature and distribution of the useful minerals; in solving the perplexing structural questions affecting their occurrence, and in facilitating the discovery of new fields.

The problems of the production of the metals and non-metalliferous substances, as we know them to-day, are of quite recent growth. High explosives, efficient engines and pumps, steam shovels and the like are all not so old as many men who are still living. They have so greatly reduced costs that practically a new world has opened to the miner. Not only on the surface or near it has he been able to work, but the depths have become accessible, and where the value of the ore justified the ef-

[1] Presidential address before the New York Academy of Sciences, December 19, 1910.

fort, no floods of water have sufficed to keep him out.

These successes coupled with ever-expanding markets have until recently directed attention almost wholly toward discovery and production. But the last ten years have brought a further change. We are now less concerned about new discoveries than about the maintenance of old ones. We are not altogether intent on production, but are much given to forecasting and husbanding. From being solely an aid to the miner, the active worker, the producer, geology has become the colleague and helper of the economist, the statistician and the philosopher.

Like all other changes in fundamental points of view, this one has not come with absolute suddenness. As far back as 1879 certain geologists and engineers began to raise and discuss the question of the duration of the Pennsylvania anthracite. In 1894 the late Richard P. Rothwell, long the able editor of the *Engineering and Mining Journal,* gave these coal fields a future of 70–100 years. Thus for over thirty years the question of their death has been a very live one. Even earlier the future of the coal-fields of Great Britain came up for discussion. A parliamentary commission was appointed in 1866 and reported upon the question in 1871. For forty years anxiety has prevailed regarding the continued production of our petroleum wells, and naturally so. The very means of production of this useful source of heat and light starts a train of thought along the lines of its permanence.

Some ten years ago, the question of our reserves in iron ore began to excite interest. Mr. Andrew Carnegie gave most forcible expression to the feeling of alarm in his rectorial address in 1902, at the University of St. Andrews, Scotland. Mr. Carnegie was known from one end of the world to the other as one of our greatest iron-masters and his words made a profound impression. In his address he assigned us only enough first-class ore to last for sixty or seventy years, and only enough of the inferior grades for thirty years thereafter. We all trembled for some years with the prospect of seeing our greatest industry in the production of metal, disappearing within a century. Many thoughtful people began to wonder what would become of us with its extinction.

I have thought, therefore, that it might be not without interest if we take up this evening the more important of our metals and pass in review some of the fundamental facts of their production, the yield of their ores, the foreign sources, the future probabilities and the effect upon the civilization of our own and other lands which would result from their curtailment. In a word, we may for a time discuss geology and economics.

The iron industry in the United States took its rise in the colonies along the Atlantic seaboard—and at the outset was based upon the magnetic ores and brown hematites there occurring. For one hundred and fifty years its growth was slow. In the decade of the forties and fifties of the past century it had spread to the Adirondacks and in the fifties began its development in the Lake Superior region. Not until after the close of the civil war and the resumption of peaceful activities did this great industry manifest its possibilities. With improved facilities of navigation which placed Lake Superior in easy communication with the coal-producing states of Pennsylvania and Ohio, the iron-ore-producing states of Michigan, Wisconsin, and later Minnesota, came rapidly into prominence. In somewhat slower growth Alabama, during the seventies and eighties gathered headway. At present four fifths

of our ore supply comes from the three Lake Superior states, and three out of the four fifths from Minnesota alone. Alabama, Tennessee and Georgia together yield one tenth and the remaining tenth is divided among a dozen or more other states, of which New York is the leader. Since 1880 the total has increased about sevenfold and Pennsylvania, then the source of about one quarter the supply, now yields approximately one and one half per cent. Minnesota, now the great source of ore, only entered the lists in 1884, and only began to utilize its present great mines about ten years later.

Thus in the brief course of thirty years there have been very great rearrangements not only in geographical sources of supply, but still more in actual amount of output. In normal, prosperous years the annual production is somewhat more than fifty million tons of ore.

But there have also been other changes not less striking. In early days and in remote situations only the richest ores could be mined. Magnetites for example in the lump from the Adirondacks afforded over 60 per cent. metallic iron. Specular hematites from the Lake Superior districts necessarily yielded 65. For some years no one regarded them with respect if they contained less. Red hematites from Alabama afforded forty-five to fifty. The minor ores near the furnaces were often much lower —but they may be passed over for the moment in emphasizing the larger features. Magnetites in the Adirondacks are now concentrated before shipping and in instances two and one half to three tons are condensed to one of 65 per cent. tenure. The crude ore carries 33–35 per cent. During the early years of the present decade the general average yield of Lake Superior shipments fell off about one per cent. per year—so that now the soft ores, so called in contrast with the hard lump specular of earlier days, range somewhat above 50 per cent. Alabama ores, once 45 to 50, now are very uniform at 36 to 37. So far as the brown hematites are concerned, which in the form of lumps, crusts, pipes, etc., are distributed throughout ochres and clays, the percentage of available iron in the crude ore is lowest of all. We wash from eight to ten tons of crude in order to get one ton of concentrates of say 40–45 per cent. in iron, and under favorable circumstances may treat much lower raw materials. Soft magnetites in Pennsylvania, which on the richer outcrops gave 45 to 50 per cent., are now dug in very large amounts with a yield of 43. If we take the total production of ore in the United States and the total production of pig iron, we find the yield in the large way to be about 50 per cent.

In order to gain some idea of the comparative merits of these figures when set alongside the percentages in the ores produced in other lands, a few cases may be cited. Germany in 1907 produced 27,700,000 tons of ore, exported nearly four millions and imported eight and one half millions. Of the local production three quarters were obtained from Elsass, Lothringen and Luxemburg, whose percentage in iron ranges between 30 and 40 and is on the whole not very different from Alabama's present percentages of 36–37. Germany's imports, of course, range much above these figures, else the ore could not stand the freight charges from mines in such remote countries as Sweden, Spain and Algiers.

Great Britain produced in 1907, approximately, 15,000,000 tons, of which about three quarters were the so-called impure carbonates yielding 30–35 per cent. iron. One ninth of the total was red hematite at 50–55. The general average would be somewhat less than that of Alabama. Im-

portations of richer ores, especially from Spain, helped to raise the furnace yield.

France in 1908 produced 10,087,000 tons, of which 88 per cent. was mined in French Lorraine of the same type as the main German supplies. The ore ranged from 33 to 40 per cent.—again not far from the Clinton ores of Alabama. We are justified, therefore, in saying that the largest part of the output of the next three producing countries of the world is about the same as the lowest grade of lump ore, which can be profitably mined under present conditions in the United States. When, therefore, we come to estimate comparative reserves we must realize that in the Lake Superior region—our greatest producer—we pay no attention to-day to ores, which are, nevertheless, much richer than those of Great Britain and continental Europe.

In the opening sentences I spoke of the anxiety which was felt a few years ago regarding the reserves upon which the industry would of necessity rely for its future. I mentioned Mr. Carnegie's remarks in 1902 at the University of St. Andrews. But he was not the only one who discussed this question and now in referring to one or two other forecasts, I think you will have in mind some of the fundamentals which establish a correct point of view.

In 1905 Professor Törnebohm, the eminent and greatly esteemed former director of the Geological Survey of Sweden, assigned to us a reserve of only one billion and sixty millions of tons. Obviously, at an annual production of over fifty millions this reserve would only last twenty years. The future thus looked still darker than when seen through Mr. Carnegie's spectacles. Much opposition arose at once, however, to Professor Törnebohm's data, because from them had been omitted the red hematites of Alabama, which can be very accurately estimated and which of themselves are thought by competent observers to have a half billion tons for the future. Additional modifications must also be introduced when we properly appreciate the downward tendency of workable percentages. The lower the percentage of iron which we require in the product of our mines, the greater the amount of ore which at once becomes available. This is peculiarly true of iron, because of its very wide, general distribution.

In 1907 in anticipation of the International Geological Congress of 1910, which was to be held in Stockholm, the Swedish committee of arrangements began the preparation of a series of estimates of iron reserves in all the countries of the globe. Geologists familiar with local conditions were requested to prepare the figures each for his own country. It fell to the speaker to start the collection of American estimates and much aid was afforded by several of the largest companies owning reserves. Shortly thereafter, however, the interest in the conservation of natural resources sprang up and Dr. C. W. Hayes, of the United States Geological Survey, was empowered to use all the resources of this great organization in assembling data on iron. In this way figures as reliable as can be expected are now available. We learn from them that we may consider three and one half billion tons of fifty per cent. ore as assured in the Lake Superior region. Of this great total three billions, one hundred millions are in the Mesabi range of Minnesota. At thirty millions of tons per annum, the present output of Minnesota, we have a reserve for a century.

On the other hand, if we drop to 40 per cent. or slightly below, still, however, remaining a few per cent. above the Alabama grade, the drill holes show above depths no

greater than those already reached in some mines, two or three hundred billions of tons of siliceous hematites, giving amounts practically inexhaustible.

In the Alabama ore beds we feel assured of five to six hundred million tons of the grades now utilized and there may well be twice that number. The conservative estimate would afford enough to last at the present output of that state longer than a century. In addition there is much reason for thinking that there may be two or three times as much.

Speaking for the country as a whole, we may say that there is an assured and demonstrated supply, at present rate of output and at present percentage of yield, for about a century. There is, furthermore, a less accurately measured but still very probable addition, when we allow for lower grade but still practicable ores, which will be sufficient to last at present rate of production for fifteen hundred years to come.

If, however, production increases, as indeed it may with a rapidly growing population, and if in this way heavier and heavier drafts are made upon even this great reserve, where shall we look for more? There may be some new discoveries within the United States, but at present it is impossible to speak definitely of them. We may ask if there are other supplies in neighboring lands. To this question we may answer yes. Along the north shore of Cuba, toward its eastern end and near the sea, three areas of what formerly appeared to be a barren, ferruginous soil have been discovered and tested, so that we now know that there are two to three billions of tons of a very pure iron ore, which, when deprived of the large percentage of water which it contains—a cheap and simple process—will yield from 40–45 per cent. iron. This variety of ore already begins to enter our ports and the deposits will undoubtedly contribute in no unimportant way to the output of our furnaces.

The report of the International Geological Congress has shown further that in Newfoundland there are quite probably more than three billions of tons of red hematite, whose present yield averages 54 per cent. From Brazil, moreover, in the state of Minas Geraes, but pretty well back from the coast and not yet opened up by rail, as estimated by Dr. O. A. Derby, there are from five to six billion tons of 50–70 per cent. ore awaiting the drill and the steam shovel. Ore from Brazil faces a long sea voyage, but the grade is rich and the iron masters of this and other countries are looking upon these deposits as well within the possibilities of the future. Ocean freights are kept at very reasonable rates in later days and once on a steamship even so low-priced a commodity as iron ore, if of good percentages and cheaply mined, can be taken relatively great distances. This is demonstrated by the shipment this year from the mines of Kiruna, 112 miles within the Polar Circle in Lapland, of 300,000 tons of ore, 113 miles to the Norwegian coast by rail, and over 4,000 miles to Philadelphia by sea, with no great prospect of a return cargo. These shipments also demonstrate that we are not without the range to which European ores may be shipped when exceptionally rich. Some portion of the vast ore body of Kiruna, with its demonstrated 500 millions of tons of 65–69 per cent. ore will also reach American furnaces.

But even were our actual ores of present grade to become exhausted, iron as a metal would not fail. The basic rocks with their low percentages still remain. The trap-rock of the Palisades contains 7–8 per cent. of metallic iron, a value that is far above the general yield of our copper ores in the red metal.

Iron, therefore, will never fail. It will probably not change in its general relations to modern conditions for a very long time to come, so far as its ores are concerned. We may have greater anxiety about the supplies of coking coals than about the iron ore, but there are always such possibilities of improvements or changes in processes that no one can justly give way to unqualified forebodings.

Copper is the metal generally considered next in importance to iron. It is a very old one in the history of the race. The bronze age, you will recall, preceded the iron age. Prehistoric man in Europe solved the mixed metallurgy of copper and tin before he learned the smelting of iron. Prehistoric man in America found native copper on the shores of Lake Superior and passed it in trade a thousand miles from its home. As a cherished possession it constituted his ornaments while he lived and it was buried with him after he had died.

Among the moderns, copper is most extensively employed in brass, but as a conductor of electricity it finds year by year increasing applications in the purest condition in which the metallurgist can supply it. If at home or in your office you look around your chair or desk you will be surprised to find how universally employed it is.

Greatly stimulated by the development of electricity in later years the production of copper has advanced by leaps and bounds. At present the United States are the heaviest producers, with Spain following next, but only yielding one eighth as much. The United States furnish over half the total. In 1850 the United States yielded 728 tons; in 1900 over 303,000 and in 1908, 471,000. Meantime in 1850 the price of copper was about 30 cents per pound. Its lowest point in recent years was nine cents in 1894. Its highest, 25 cents, was attained in 1907. We may each of us imagine the variation in the profits of a mining enterprise as between 11 cents a pound and 15 cents, let alone 20 or 25 cents. Mining costs, smelting and freight charges, show no such variation, so that with rising prices profits greatly increase. Indeed, few of the metals have such extraordinary ups and downs as does copper.

In its ores the yield varies greatly. On Lake Superior, where the native metal is distributed through ancient lava flows in little pellets, leaves and sheets, it has been profitably mined and produced through periods of years, when it constituted but three quarters of one per cent. of the ore. The general run is, however, one per cent. and above. If we recall that in a ton of 2,000 pounds one per cent. is 20 pounds, and three quarters of one per cent. 15 pounds, and if copper is selling at, say, 13 cents, the mining manager must break down, hoist, concentrate with attendant losses, and smelt an ore worth less than two dollars for all the metallic contents which it contains. We can thus gain an idea of the close and economical work required and the ability demanded of a manager. As the price rises the profits greatly increase, and temporarily idle mines are brought within the widening remunerative zone, and are quickened into life. As the price falls, the mines dangerously near the line close down and production ceases. The lowest cost of production claimed is from the low grade and very large ore bodies of the west and is placed at or about eight to nine cents per pound laid down in New York.

In copper ores outside of the Lake Superior region, we usually find the metal in composition with sulphur. The ores as they come from the mine may be rich enough to go directly to the smelter, or they may require concentration before the

grade is sufficiently high. The ores which are directly smelted reach the minimum of copper in the Boundary district of British Columbia, but associated gold and silver raise the value per ton above four dollars. Copper ores yielding copper alone were smelted at Ducktown, Tenn., during long campaigns at a little less than 2.5 per cent. In earlier years and in many mining districts ores as high as 20 per cent. were found, rarely even higher, but they in time were exhausted and five per cent. would be quite rich for day in and day out averages.

These statements will serve to establish a point of view and likewise afford a standard of comparison. What is the outlook for the future of copper production?

We can not predict copper with the certainty of iron. It seldom appears in bedded deposits which can be measured. In the deep mines we can not always see ahead for more than a year or two. In some mines we know from exceptionally complete development, of twenty years' supply. But the great advance in copper mining has been the entrance of relatively low-grade ores into the productive field. The wall rocks of ten years ago have become the ores of to-day. Where we find in porphyries or schists copper sulphide disseminated in fine particles or as coatings along crevices, and in sufficient richness to yield two to two and one half per cent., throughout very large bodies, it can be mined very cheaply and concentrated in enormous quantities so as to return a safe margin. If the ore lies near the surface, steam shovels make excavation extremely low in cost. The huge pits and open cuts of this type of mine in the west are now among the great sights for the traveler. Mills whose insatiable crushers take as much as eight or ten thousand tons per day are no longer unknown. The drill blocks out the ore long before mining begins, and reserves can be estimated more closely than in the vein mines.

If a mine is called upon to furnish a mill with 2,000 tons per day and we allow 300 working days in the year, 600,000 tons must be supplied per annum. For a life of twenty years, a time practically demanded of such an enterprise to justify the great expense of installation, at least 12,000,000 tons must be shown by the drill before the enterprise can safely begin. If we expect to mine three times this amount per day we call for three times as much ore. These figures, large as they may seem, are not beyond the estimates of ore bodies as now blocked out in several places in the west, and even with these great demands, twenty years supply and even more in instances have been demonstrated.

Let us now imagine again a 2,000-ton daily output of say 2.25 per cent. ore, of which the mill saves two thirds, or 30 pounds of copper in the ton. The output in copper per day will be 60,000 pounds, or 30 tons and for the year 9,000 tons. Should three new companies start up with four or five times this output, 36,000 to 45,000 tons will be added to a yearly supply, which in 1909 was 552,668 tons. We see great need of a growing demand in order that these vast contributions may be absorbed. Yet I have made no unreasonable assumptions nor have I overstepped the practical certainties of the next few years.

How long will our copper hold out? Mines come and go, and for the immediate future there will certainly be no scarcity. Copper does not oxidize as readily as iron and is not lost. The world's stock steadily accumulates. But twenty years is not a long look ahead. Are there new countries which will be producers? Some of the old mines in Europe are now no longer great sources of the metal.

We do know of possibilities in Alaska that will add some contributions. We know of new or recently opened ore bodies in Peru, Bolivia and Chile that promise well. We hear of very large deposits in the southeastern corner of the Congo State, once worked by the ancients, now revived by the moderns and possessing large reserves of 15 per cent. copper ore. The Cape to Cairo railway will give them great impetus. For the immediate future there is no lack, but if we look fifty years or a century ahead we can speak with less confidence. In a general way we may say that probably new discoveries will, for a time at least, more than keep pace with demands. But when we look fifty years into the future we are not so certain. It behooves the producers to use no treatment of an ore except a careful and economical one. If tailings and waste from our mills now contain one third the copper in the original ore, they should be impounded and kept from being washed away by floods, against the possible call of the future. We dare not say that they will never be within the ranges of profitable treatment even though their low percentage places the copper beyond reach to-day. The copper situation is not one to excite anxiety, yet it is also one not to encourage extravagance.

Following copper we may take up lead and zinc, which are the next metals in amount of production. Of the three, zinc is the least in total tons and in total value. We may gain some idea of the relations from the small table given below in which zinc is taken as unity and the figures relate to 1908.

	Amount	Value	Price per Pound
Zinc	1.0	1.0	1.0
Lead	1.6	1.45	0.9
Copper	2.46	7.0	2.8

Thus we see that the lead production is one and three fifths that of zinc, and the copper is two and one half times; that the lead is about one and one half times the value of the zinc, and the copper is seven times; and that zinc is worth more per pound than lead and only about one third as much as copper. The red metal is not only produced in greater amount, but is worth more per pound and in the aggregate than both the others taken together.

Among the nations of the world the United States has become the chief contributor of lead and yields year by year proportions varying from 27 to 33 per cent. of the total. The next country is Spain with about two thirds as much, and Germany follows with three fifths.

In this country the state of Missouri is the heaviest contributor and is responsible for practically 40 per cent. of the total. Idaho is next with about 32 per cent. and Utah follows with 13 to 14. The western lead all carries silver. The precious metal is an important factor in the value of the product. When we come to forecast the future it is not possible to see more than a few years in advance or to speak in more than a general way. The miners would be glad to be assured of reserves of ore for a goodly period of years, but it is seldom possible or practicable to demonstrate their presence. Operations necessarily continue with a few years' supply blocked out in advance of the actual mining and the hope is maintained that more will be found. Very often the expectations prove justified. We may therefore in a measure forecast future experience somewhat by the past. In the Missouri lead region mines have been operated for forty or fifty years, not on so large a scale at the outset as now, but continuously. For some years at least no change may be anticipated. In Idaho the lead ores are now known to continue to

depths of nearly 2,000 feet beneath the overlying surface and to be holding out without essential change in character. In Missouri, however, the mines never have been very deep, that is over three or four hundred feet, and the compensation comes in wide horizontal extent.

Some of the old time heavy producers have greatly declined. Nevada, once an extremely important source of lead, is now a comparatively small contributor. Colorado, in former years our chief source, has dropped to only a third of its one-time yield, and yet the total of the country has gone quite steadily on. The fall in the price of silver was a hard blow to the western lead miners and naturally not only cut off their profits, but raised the necessary percentage of metal in the ore.

If we look ahead for a century or some such long period, we may not feel assured that production can be maintained at present rates. There may, of course, be new discoveries in lands not as yet fully explored. Being distant from present centers of consumption as they necessarily would be, their entry into the markets would imply higher prices so as to meet the charges of freight.

On the other hand, lead is a metal which oxidizes or changes very slowly. In its applications in the metallic state it tends thus to accumulate unless lost in use, as in the case of shot and bullets. It is extensively employed in the manufacture of paint and in this form is of course never recovered. About two per cent. of the entire output is destroyed to give us white and red pigments.

It behooves us on the whole to be careful in the use of lead and to avoid, when possible, its unnecessary sacrifice.

Zinc is a metal of comparatively late introduction into commerce in the large way. Although known for centuries, it has found its chief applications in the last sixty years. There was no zinc mine in the United States until approximately the year 1850, and from the Missouri region whence we now obtain our chief supplies, the really serious contributions began about 1870. Lead, indeed, was mined and prized long before this, but the associated zinc ore was thrown one side on the dumps. In the west the same experience continued until much later. Zinc was a nuisance in the metallurgical treatment of lead and even the lead was sought and smelted either because of its own silver contents or because it made possible the treatment of other refractory silver ores. In the metallurgical work the zinc was volatilized or slagged off and was lost. Indeed, one of our most serious metallurgical problems has been the successful treatment of lead-zinc ores and many investigators have addressed themselves to its solution. Now that anxiety is beginning to manifest itself regarding zinc supplies for the future, the desire to save it is stronger than ever.

Zinc, however, is a peculiar metal and because of the exigencies of its treatment its ores must possess greater richness and greater purity than those of other base metals. Thus in the case of copper a ten per cent. ore is in later days phenomenally rich, and as it can be smelted in a shaft furnace the presence of iron or lime or other bases that make fusible slags is an advantage. But zinc ores, perhaps after preliminary roasting, must be reduced and the metal must be volatilized at a high temperature from a small charge in a retort. The presence of fusible bases destroys the retort and the bases are therefore debarred beyond certain small percentages. Thus it happens that a forty or fifty per cent. zinc ore might be valueless if contaminated by iron or lime beyond a narrow margin. While almost any con-

ceivable mineralogical aggregate that contained ten per cent. of copper would be a very valuable ore, a zinc-bearing aggregate with four or five times as much zinc might be unsalable.

Suppose we compare them from another standpoint. Copper ores, if at all profitable, are worth about so much per unit of copper, that is, so much for each per cent. While there is some variation yet the contrasts as among three per cent., five per cent. and ten per cent. ores are much the same as the ratio of the per cents to each other. But if we think of a zincblende ore or concentrate of 60 per cent. as the standard of richness, a fifty per cent. ore is not worth five sixths as much, nor a forty per cent. ore two thirds. On the contrary a forty per cent. ore might be entirely unsalable. As the zinc decreases other deleterious bases take its place and a worthless mixture soon results. Zinc is in many ways the most peculiar of the metals and when we come to deal with its profitable treatment analogies with other metals fail.

In 1907 the United States were the chief producer of zinc among the nations, but, as a rule, Germany leads, followed by this country and Belgium in the order named. In later years our output has varied from 26 to 30 per cent. of the total. As a rule Germany is 2–4 per cent. in excess of us and Belgium is 4–5 per cent. less.

In America, Missouri is the chief source of zinc. Its production from the mines was in 1908, approximately one half the output of the entire United States. New Jersey follows with somewhat over one quarter the total, while all the rest are much smaller.

The Missouri ores as thus far produced have been obtained from comparatively shallow depths. They extend lengthwise and sometimes laterally to greater dimensions than vertically. While it is not beyond the possibilities that lower lying deposits may be discovered, since zinc ores are found in Arkansas in strata of lower geological position, anticipations of this reserve have not as yet been demonstrated on a large scale. Kansas, Oklahoma and Arkansas, the states neighboring to southwest Missouri, also have some zinc ores, but they are not of great importance; southwestern Wisconsin is a very old mining district and has many small mines, which were earlier worked for lead. They have been revived for zinc in later years and are now an appreciable but not great factor. They may develop somewhat more extensively and may last for a goodly series of years, but the mines are relatively small and are wet, so that exploration does not go very far in advance of mining.

In New Jersey the future is best forecast of all. For thirty or forty years there is no occasion of anxiety. Yet thirty or forty years pass quickly and then we must prepare to look for other sources. To make the zinc blende of the Rocky Mountain region available, an increase in price is practically necessary, otherwise the metal can not stand the freight charges. There is zinc ore in the west but to what extent we can not well say. It has been avoided rather than sought in most of our mines. Yet we do note symptoms of attention to it. In Butte, Montana, efforts are being made to concentrate it. Shipments of oxidized ores have been made from New Mexico for some years past. Until recently large amounts of peculiar appearance seem to have been overlooked at Leadville, Colorado. They promise to be an important resource. A government commission has reported upon the occurrence of the metal in British Columbia in the hopes of utilizing the ores. From Mexico, too, we learn of explorations for zinc. Conditions are changing in the case of this metal and

more and more it is certain to be brought from remoter localities. But when we look a long way ahead, say for a century, we can not feel free from anxiety. This condition of mind is even more prominent in Europe than in America. The waning of the famous old mines near Aix la Chappelle, and the apprehensions felt regarding other sources, have led to a world-wide search. Zinc ores, for example, now reach Hamburg from the Pacific shore of Siberia, and as other discoveries are made, additional points remote from present smelting centers are likely to be shippers, provided that transportation is by water. Nevertheless, all these new conditions call for advances in price and before many years zinc bids fair to take the upward course.

The precious metals, silver and gold, are the only other two which we may pass in quick review. Silver is a less profitable object of mining than it was twenty years ago, and yet with the improvement of processes of extraction and with the great development of the output of copper and lead in which it is a by-product, the fall in its price of the early nineties has been less disastrous to the amount produced than one might have supposed. Our maximum output was reached in 1892 when it was 63,500,000 ounces valued at $55,662,500. In the same year about 1,600,000 ounces of gold were produced valued at somewhat over thirty-three millions of dollars. In 1908 we are credited with approximately fifty-two and a half million ounces of silver, valued at twenty-eight million dollars. Gold, meantime, with the fall of silver, has advanced to 4,574,340 ounces, valued at $94,560,000.

In the United States we have now comparatively few distinctively silver mines. Among them Tonapah, Nev., has been chief. Mexico is the particular home of silver, but the remarkable district of Cobalt, Ontario, has given great present importance to Canada. In our own country we must expect the white metal to share the fortunes of the copper and lead with which it is chiefly produced. As influencing its future, copper is a more serious factor than lead, both for the reason that Missouri lead contains little if any silver, and because western copper ores display greater reserves than do western lead ores. As sources of silver there were in 1908 no very great differences among Montana (a copper-silver state), Colorado (a silver and lead-silver state), and Nevada (a silver state). Utah (both a lead-silver and a copper-silver state) afforded about five sixths Montana's output; and Idaho (a lead-silver state) about three fourths Montana's;[2] Arizona (a copper-silver state) follows after a long interval, and the others are much smaller.

As an indication of relative magnitudes, while the output of the United States was placed at 52.5 million ounces in 1908, Mexico afforded 72.6 and Canada 22 millions. Australia with 17.3 follows and then Peru with 7.2 millions. A metal with so high a value as silver will stand transportation from remote points, and although the production in one country or another may fluctuate, the world's supplies are not likely to be seriously affected for many years. Silver is largely used in the metallic state, and, being resistant to change, it tends to accumulate. Photography is the most destructive industry to it, and when once employed in this art, it is practically lost.

[2] In ounces they range:

Montana	10,356,200
Colorado	10,150,200
Nevada	9,508,500
Utah	8,451,300
Idaho	7,558,300
Arizona	2,900,000

Gold is mined for itself alone to a far greater degree than is silver. Thus in this country in 1908, almost 93 per cent. of the gold was produced without regard to other metals and only 7 per cent. was obtained with copper and lead: whereas about 60 per cent. of the silver was produced in association with the base metals. Gold in later years has increased in amount of production beyond all previous experience. The steady and scientific digging and washing of low-grade gravels are, in the long run, more productive than the rich skimmings of the early California, Australia and Klondike placers. The world's total of 444 millions of dollars in 1908 was in excess of any previous year. The Transvaal furnished the most, nearly 146 millions. The United States followed with 96 millions; Australasia yielded 72.5; Russia nearly 40; Mexico, 24.5; Rhodesia, 12.2 and British India, 10.4. All the rest were under 10. The countries mentioned supply about 90 per cent. of the total.

In the United States 28 per cent. of the gold comes from gravels and these are the least permanent of the sources of the metal. With their exhaustion the output will decline. In the deep mines there are signs of waning output in some districts. In our own country new districts have come to the front from time to time to give on the whole a steady increase in output for forty years past. So far as the future is concerned, however, the ups and downs of any one or of several countries make slight difference in the world at large. Gold can be readily shipped from point to point and the place of its production is a comparatively small matter.

Like silver and to an even greater degree it resists chemical change, so that the world's stock constantly augments. No very important portion is permanently lost in the arts.

Gold and silver are so extensively employed in coinage that they have received more attention at the hands of economists than have any other metals. Gold in later years, with its increasing production has led to much philosophical speculation. The establishment of it as the monetary standard and the elimination of silver from this position have occasioned some of the most heated political controversies in the history of our country. Into these a geologist is not competent to enter. We all probably realize from old-time experience how easy it is to become befogged. But the geologist can say that for some years to come the gold production will undoubtedly be maintained. And that while the Klondike and Alaska may wane, Siberia will increase.

We may now briefly summarize the main facts affecting the six metals which have been passed in review. It will then be possible to draw some general conclusions. Of iron ore there is no lack, nor need any one be apprehensive regarding the supply of this metal, but before very many years have passed the yield of the ore will have decidedly declined. While the falling off will be gradual, it will undoubtedly tend in the long run toward forty per cent. This change is in itself important because, unless otherwise neutralized it will raise the cost of production. It makes necessary the melting of more barren materials in the furnace, so that the consumption of fuel rises with respect to the amount of iron produced. It means also the mining and freighting of an additional burden which yields no return. From whatever point of view we regard it, other things being equal, the cost of production rises. The great reserves of lower grade ore than at present mined are in the Lake Superior district. They are siliceous ores, and will require in smelting the admixture either of limestone

or of other iron ores high in the bases. The Clinton ores of Alabama are of this type and except for the unfortunate percentages of phosphorus which they might add to Lake Superior ores, they would doubtless make an advantageous mixture with the latter. But the southern ores are remote from the northern. In order to meet them at or near the supplies of fuel a long railway haul would be necessary. While this is not impossible, it would add to the cost so greatly as to be highly improbable. There is one further consideration. The greater part of our pig iron is used in the manufacture of steel. For this purpose in the two processes most extensively employed hitherto, we need, respectively, either a very low or a fairly high percentage of phosphorus. If our irons are in between, and like the church at Laodicea, neither hot nor cold, they have been ill-adapted to steel manufacture. Unless the growth of the open-hearth process introduces great changes, the mixture, therefore, of southern basic ores and northern siliceous ones is not altogether promising for this reason.

The greatest cause of apprehension as regards present processes of iron manufacture lies in the supply of coking coal. We have built lofty furnaces, and in their use we place upon the fuel as it progresses downward in the furnace a heavy load of overlying ore and limestone. We need a very strong coke to stand up under the burden. The coals which yield these high-grade cokes are found in a small portion of the total coal-bearing area, and the life of the supply is one of the very serious phases of the present situation. I do not know what the amount of reserves may be.

While these physical and chemical factors operate to increase costs, there is always the possibility of improved processes and of greater efficiency to keep them down. The improvement oftenest in people's minds to-day is the utilization of water powers to generate electricity, which in turn may supply heat. Now, in a blast furnace smelting iron ores, one third the fuel is employed in reducing the iron oxide and two thirds in developing the necessary heat for the reaction. Were we able with water powers to economically furnish electricity and from it derive the necessary heat we might save the two thirds of the present amount of required fuel. We might reduce costs. The remaining one third of the fuel we should always need but it is possible that poorer grades than high quality coke might answer. The saving would lie, of course, in the difference between the cost of the fuel and the cost of the electric current, provided the latter could be furnished more cheaply than the former.

The water powers in our own country or at least in the more thickly settled portions of it, have not failed to attract attention, nor have they gone altogether unutilized. The more conveniently situated ones are already harnessed to the dynamos. But in countries like Norway and Sweden, where there are large water powers still available, where there are rich deposits of ore and where coal fails, the applications of electricity to iron smelting are likely to be first worked out successfully. Data may be furnished in the life-time of many of us, which will cast light upon these improvements in their world-wide relations.

The only other apparent possibility of reducing costs lies in the labor charges. Wages at present are not unduly high, and unless the increasing population of the country brings to pass an inevitable struggle for existence, which will cause the greater subdivision of tasks at lower proportionate returns or unless the general reduction of expenses for subsistence makes lower wages possible, there would seem to

be slight prospect of change in this item. In any event the reductions from this cause can not compensate the falling off in the yield of iron as foretold above.

Suppose iron goes up in cost—other conditions of our daily life remaining the same—transportation and all manufacturing based on machinery would become more expensive; and less freely carried on. Undoubtedly an appreciable pressure would be developed to turn our people back to the rural districts and to tilling the soil for a livelihood. The tendency under the stimulus of manufacturing development has been the other way. The migration of late years has been toward, not from the cities. Shall we perhaps find in the long run, in the increasing cost of iron and steel a partial solution of a much vexed problem? Will the cry "back to the soil" receive support in a way not generally anticipated? The question is an interesting one for speculation.

The general inference regarding copper is that the pinch of higher cost of production will be felt sooner than in the case of iron. We have no knowledge of such enduring reserves of copper ores as we have of iron. On the other hand, copper, despite its vast importance, is not the fundamental necessity that is iron. It is used in less quantity in machinery and its increase in cost would less vitally affect manufacturing industries based on machinery. Advancing cost would cut it out of much ornamental work of inferior esthetic merit. The most serious effect would be found in raising the expenses of service in the applications of electricity. Electrical transportation, telegraphy and telephony would be more expensive than to-day. Unless wireless methods of transmission eliminate copper, or unless some discovery in the domain of physics which we do not now foresee furnishes a substitute for the omnipresent copper wire of to-day, we may find ourselves face to face with some curtailment in these modern aids to the easy conduct of life's affairs. If in the course of several centuries the falling off in supply and the growth in population should raise copper to relatively high figures, we may wonder if a return in a way to the conditions of the middle ages will not result. Will copper then become to a greater degree than now the basis of skilled handiwork? Will the by-gone craftsmanship be revived and with a lessening total output shall we see an advance in artistic skill? In fact, if the vast development of machinery and the huge output of metallic objects at low cost—a condition so characteristic of to-day—should be checked or curtailed, would not hand-work on more valuable mediums of expression be restored. It is not altogether unreasonable to anticipate fewer objects and higher crafts in their production.

The cases of lead and zinc are even more emphatic than that of copper. We have still fewer assured reserves and the pinch of increasing cost may manifest itself at an earlier date. The two metals are not, however, quite such vital factors in modern life as is copper and the larger effects would be less apparent. Zinc is a necessary component in the manufacture of brass, which industry absorbs the greater part of the copper output. A curtailment of either lead or zinc would cause inconvenience, but would scarcely occasion fundamental changes.

Silver will be very seriously affected by a decrease in the output of either copper or lead. Gold will feel these changes in an appreciable but far less degree. There will always be sufficient, however, of each of the precious metals for coinage, and beyond this use their applications, except perhaps in photography, concern luxuries rather

than fundamental necessities. We can not attribute to them any profound possibilities in their influence upon civilization should the contributions of the mines decline. In the recent past we have been more apprehensive regarding a too great supply of the precious metals, than regarding one too small.

With the increasing interest in the discussions of the conservation of natural resources, there has been an increasing disposition of the authorities to assume supervisory powers over mining and metallurgical operations. The old-time idea that to the crown, or, as we are accustomed to say, to the state, belongs the mineral wealth of the earth, is experiencing something of a revival. The disposition to restrict the waste of valuable metals or minerals in processes of manufacture is commendable and after careful demonstration that it is feasible and just to the operating concerns, it may be wisely done. The rejected product of concentrating mills or the "tailings" so called, when provided with appreciable percentages of metals, may well be stored where they can be utilized by future generations, if processes improve so as to make them available. That is to say, they should not be run into rivers, or placed where they will be dissipated. The same remark applies to slags from metallurgical works. The moderns, for example, are now working over the lead-bearing slags left by the ancients at the great lead mines of Laurium, Greece. Even the slags of early smelters in the west and Mexico may again pass through the furnace.

Another question relates to the discovery, location and ownership of mining property. So far as the metals are involved, and with the metals this address has been alone concerned, the valuable discoveries are so few in comparison with the disappointing attempts to develop, that only by encouragement and rather generous conditions will the prospector be enabled to follow his arduous calling. He must be offered large prizes proportionate to the many failures. He must be assured of possession by a very circumspect and conscientious administration, if confidence in the justice of the government is to be maintained. People in the parts of the country where mining for the metals is not carried on hear only of the great successes and little of the innumerable disappointments. Far the largest part of the population thus acquire very distorted views of the real conditions of mining. The interference by the government other than in the ways which I have mentioned and in maintaining reasonably safe conditions for the workman, is a matter to be regarded with great caution, lest irreparable injury be done to the large problem of maintaining our future supplies with such new discoveries and developments as may be feasible. The wisest course is to improve the method of establishing and recording titles to new discoveries, and then, except in the matters already mentioned, to let the natural course of business assert itself. The proper share of the state will be obtained through the normal processes of taxation.

The mines for the metals do not, however, present the most important phase of this subject. Coal is a more serious problem, and one demanding more extended treatment than would be justifiable in an address primarily devoted to other themes. One may only express the hope that where cases of dispute arise they may be determined in the courts, according to the established rules of evidence.

The resources in the metals which have been found in the United States have proved so great as to make the industries based upon them a very vital factor in our

whole civilization. Great changes in the supply or the cost will inevitably react in the long run upon the opportunities for employment and support, and upon the very nature of our national life. While it will be a long time before rearrangements in the case of the most important of the metals, iron, will be manifest, and while they will assert themselves gradually, we are quite certain to face new conditions in copper, lead and zinc at an earlier date. In the end, however, we can perhaps justifiably forecast a future in which agriculture will figure more and more prominently and in which the moral, intellectual and spiritual life of the nation will readjust itself accordingly. Great and concentrated wealth is likely to be less in evidence, materialistic influences less pronounced, and from the vantage ground afforded by the greater comforts and opportunities of modern life as compared with that of a century or a half century past, we may in the distant future look forward to an evolution upon somewhat different lines. Broadly viewed, the national life will probably be increasingly sympathetic with art and with ideals.

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CITY SANITATION[1]

Great cities have grown and passed out of existence. The enormous increase in urban population in very recent years has produced even greater cities, which may also in time cease to be. In fact, aside from the possibility of local or cosmic calamity, this is sure to occur, unless due attention is given to the application of the principles of chemistry in our daily, personal and communal life. London, Paris, Bombay, Rome and New Orleans have had their scourges in the past to testify to the fearful penalty of ignorance and neglect.

Indications point to an urban growth and development, the conception of which taxes the imagination. When we see New York as it was two hundred years ago, and then one hundred years ago, and as it is now, we may well wonder what it may be fifty years from now. The annual increase in population is about 300,000. It has been calculated that in 1920 New York may have 7,000,000 of people.

It has been predicted by a close and conservative student of sociology that two generations may see the eastern part of our country mainly composed of contiguous cities. In 1790, 3.3 per cent. of the population of the United States was urban. It was 33.1 per cent. in 1900. The problems of the state and county become closely interwoven with those of the city. The city will no longer be merely an accumulation of human beings in a particular locality, with its local problems and influencing the state mainly in a financial way, but the city will have become the state.

The individual needs fresh air, pure water, good food, safe shelter, and should have a clean body and something beautiful to look at. When he associates himself into a city his needs are not lessened, but emphasized. The growth of a city causes it to assume, willingly or no, corresponding obligations. The inhabitants must breathe, they must be fed and watered, its wastes must be got rid of, facilities for the safe coming and going of its people at all times must be provided, as well as protection from fire or other adventitious circumstances which concern the welfare of the citizens. The needs thus simply stated are to be met by obligations which become more and more complex with the increase in population. In fact, most of the city's problems are of comparatively recent date.

[1] An address at the tenth Conference of the Health Officers of the State of New York, Buffalo, N. Y., November 17, 1910.

With your permission I shall address my remarks to certain specific matters which have come under my observation in Greater New York, and to which I have given special study. No doubt these matters have already been considered in some of your conferences, but the public expression of the independent point of view of one unhampered by official ties may serve one good purpose, namely, of provoking discussion, which can be made profitable.

The consideration of the air of cities involves not only the principles of ventilation, which will not be considered here, but the construction of the streets, means of transportation, the disposition of wastes, and the handling of the more unusual contaminants, which vary with conditions.

There are more than 2,000,000 miles of public roads in the United States outside of municipalities. These roads in many cases are essentially the same as we find in the outskirts of our larger cities, and are the roads of the smaller towns. The town roads are traveled very much more, so the actual facts at hand for the average road are applicable to the town roads, for which no satisfactory data are available. Cushman has calculated that 500,000 tons of dust are raised on the public roads per day, or, taking 100 dry days in the year, 50,000,000 tons of material are taken from places where it is needed and placed where it is undesirable by the movement of ordinary vehicles. A discussion of economic principles of road conservation is not germane to our subject. Suffice it to say that the modern motor-driven vehicle is not a dust maker, but a dust raiser.

The dust problem did not begin with the introduction of the automobile, although it has undoubtedly been accentuated by this mode of travel. There are sections of our country at the present time where the roads have been rendered practically dustless, and neither horse-drawn vehicles nor automobiles can now deposit the dirt of the highways in the gardens and houses of abutting property owners. This condition of affairs did not exist before the introduction of the automobile, but has been arrived at in answer to the demand which has followed its use. In short, there are many suburban communities in which life to-day is far more agreeable, pleasurable and possible than it was before automobiles came into use.

Why may we not have this in every city?

Aside from the personal discomfort from flying particles of solid material, whatever be its nature, these particles are the bacterial aeroplanes. Sedgwick has shown that 10 liters of air taken five feet above a macadamized street in a dust storm may contain as many as 200,000 micro-organisms.

There is a natural fouling of the street surface and an unnatural fouling. The natural comes from excrement from animals,[2] detritus from wear of pavements, soot and dust from the air, leaves from the shade trees, and the grindings from tires and shoes. The unnatural, or, rather, avoidable causes are: refuse thrown or swept upon the streets from buildings, refuse thrown by careless users and refuse spilled from vehicles carrying material through the streets. The latter causes are supposed to be prevented by the operation of ordinances which are honored in the breach, and these causes result in the greater cost of cleaning,[3] as the sweeper has considerable work in collecting litter before attacking the dirt, and the material is bulky.[4]

Commissioner Edwards, of New York City, says in *Municipal Chemistry* that

[2] One thousand horses will, in every working day of eight hours, deposit about 500 gallons of urine and 10 tons of dung upon the pavements. "On the Utilization of Stable Waste," see Birchmore, *Journal of the Society of Chemical Industry*, 1900, Vol. 19, p. 118.

[3] For cleaning all the boroughs in Greater New York of garbage, ashes, refuse and street sweepings, the Board of Estimate and Apportionment allowed an appropriation of $7,418,299.20 for 1909, and this amount was divided among the boroughs, Manhattan receiving $4,230,441.70; The Bronx, $560,371.30; Brooklyn, $2,492,481.20, and for general administration, $135,005.

[4] Very, "Municipal Chemistry," McGraw-Hill Pub. Co., 1910, p. 243.

There are two general methods for disposing of street dirt; namely, it may be picked up, swept up, or shoveled up, and then hauled away, or it may be washed into sewers through the agency of water, or there may be a combination of these methods.[5] As a rule, a considerable portion of the dirt is conducted away during rain storms, and some cities have especially constructed their sewers with the view of conducting off all dirt which can be reasonably emptied into them; in fact, it may be said that many municipal engineers consider that the sewerage system of a city should be constructed in such a way that it will carry off a large portion of the fine dirt from the streets.

I will go further and say that the streets should either be made dustless or wet down with dilute chlorine water, that is, a solution of bleaching powder, or other disinfecting fluid. Both methods have been used with success and are within reasonable cost.

The topography of a district in which urban population has massed itself will, in a measure, regulate the mode of growth. Although improved methods of rapid transportation have overcome the necessity of concentration, yet business and other causes continue to make for centralization, with consequent elevation in the value of land, whose acreage is increased only by vertical expansion. The modern subway comes as a result. The air from the streets is sucked into these human mole holes. It is to be hoped that the Public Service Commission will not allow the construction of any more subways, or that subways be built in other cities, except that the tracks be separated by partitions, or that the tracks of trains going in opposite directions will be kept in different compartments. These have now been included in the specifications for the proposed subways in Greater New York. For, although much street air enters the tunnels in New York at present, a large portion of the air is simply churned by the passing trains and not quickly and properly replaced. The ventilation in the London Tubes and in the Pennsylvania-Long Island Tunnels is excellent.

There are many incidental impurities in city air that are local and more or less evanescent. I have shown that in the city of New York about 1,300 tons of sulphur dioxide are poured into the air daily in the combustion of coal. This is a sad annual economic waste of a most important chemical, some millions of dollars in value, which we do not know how to avoid or save at present.

The smoke problem has confronted every city where coal is used as the main fuel. Civilized nations are only beginning to awaken their "conscience of fuel." Our methods of utilizing coal give us a return of only five per cent. of its energy when burned, and only one per cent. when we convert that energy into electric light in the city.

Good firing is admittedly an important factor in smoke prevention, and it has even been regarded as the main factor of the problem;[6] but many authorities favor the distribution of gas as a means of at least alleviating the smoke nuisance.[7]

There have been many complaints against some of the railroads running out of New York City, because of the nuisance caused by their use of soft coal. Some of the suburban towns have taken legal action to prevent this. The solution of the smoke problem on the railroads reduces itself to the use of hard coal or oil, as the application of mechanical stokers and smoke-consuming devices to locomotive engines has

[5] Vacuum street cleaners have so far proved to be too expensive.

[6] Caborne, *Jour. Roy. San. Inst.*, 27, p. 142.

[7] For example, Lodge, Des Voeux, A. J. Martin and A. S. E. Ackerman; in this connection, see *Jour. Roy. San. Inst.*, 27, pp. 42, 64, 80, 85.

not proved to be a success, or better still in electrification.

The theory of Rayleigh[8] for dispelling fog, and with it smoke, by electrification is interesting and is demonstrable in a beautiful way on a laboratory scale, but the expense entailed and practical difficulties involved preclude its favorable consideration. However, this method is being used with more or less success in some of the smelters in the Pacific states.

One of the worst smoke nuisances about New York during the past few years has been caused by the garbage and other reduction plants at Barren Island.[9] During this process of reduction, oil and grease are extracted from animal and vegetable matter, leaving a dry residue, which is used as a base for the manufacture of commercial fertilizers, the discarded residue being burned in the plant as fuel.

At another plant in this same point the carcasses of the larger dead animals, which are transported by a regular line of boats, are burned. When the immense number of carcasses ordered removed annually by the New York Department of Health is taken into account, it is not surprising that the smoke given off with the accompanying odors should give offense to residents for miles around. The number removed during the past year included 19,000 horses and about 380,000 dogs and cats, besides about 1,000,000 pounds of condemned meat, about 80,000 pounds of "too gamey" poultry, about 3,500,000 pounds of fish and about 5,000,000 pounds of offal.[10]

The necessity for a suitable supply of potable drinking water is now well recognized in every civilized community, and it is usually provided in the city, often at great expense, yet an appalling degree of ignorance is still encountered in the country districts that is difficult to overcome. A large percentage of urban population does, and it is most desirable that every single individual in the city should, enjoy a few days or weeks in the country in the summer. The ignorance of country habits is proverbial with the urban citizen, who takes certain matters for granted. It is, therefore, not infrequent that these outings, picnics, etc., which should make for the better health, are the direct causes of unnecessary illnesses attributable directly to the drinking water, for all the liquid refreshments on these occasions are not limited to the national German beverage.

This is largely a matter of education. Every teacher of chemistry has a splendid opportunity to drive these simple matters home, and I never fail to do it with the five or six hundred young men who sit under me every year. But every citizen does not listen to lectures on sanitation, although frequent opportunities are given by the various lecture bureaus. Popular bulletins, such as those splendid sheets which come so regularly from Dr. Evans's office in Chicago, can do much good. The press, when appealed to, will render great assistance.

The public is inclined to believe that when an ample potable water-supply has been provided, all that is necessary has been done. Sanitarians know that the contrary is the case. They may point out to the citizens that sewage disposal is quite as important. They may cite the story of Dantzic, which had good water in 1869, but the typhoid rate did not decrease materially until 1872, when sewers were added. Vienna had good sewerage and bad water up to 1874; the death rate was 340 in 100,000. That year good water was supplied and the rate dropped to 11 in 100,000. With good water and no sewage the soil becomes saturated with refuse matter, a hot bed awaiting the planting of pathogenic bacterial seed. Sedgwick, referring to cholera, figuratively states that "Pettenkoffer has given the key to the whole situation by saying that filth is like gunpowder,

[8] *Jour. Roy. San. Inst.*, 29, p. 42; and *Elec. Rev.*, 47, p. 811.

[9] Parsons, "Municipal Chemistry," McGraw-Hill Publishing Co., 1910, p. 333.

[10] Parsons, *loc. cit.*

for which cholera is the spark. A community had better remove the gunpowder than try to beat off the spark; for in spite of their efforts, however frantic, this may at any time reach the powder, and if it does, is sure to blow them to pieces.'' The next great problem that New York City must solve will be that of sewage disposal. It will involve an expense vastly greater than the colossal sum now being spent for the magnificent new water supply.

Half the cost of living goes to pay for food. The centralization of population requires its transportation to the centers, but it does not enforce its exposure, uncovered in the streets or shops, where it collects the dirt and attracts flies. For a century it has been known that certain kinds of food could be preserved for later consumption without injury to health. There is no objection now to the preservation of food, provided it is done in the proper, that is, harmless manner. The adulteration and sophistication of food are outgrowths of the development of the city and the improved means for world-wide transportation, coupled with the degeneracy of those who live by bartering and their desire for luxuries. The chemist has been the Cartouche and Sherlock Holmes in the abominable business. Yet ignorance and disregard for the consequences so long as gain resulted have been behind the supply of one particular food, milk, which is the main support of the weak and helpless. The government has formulated satisfactory laws against the adulteration of the coin of the realm and enforces them vigorously. We have food laws now, but they are not satisfactory, nor are they always properly enforced. In fact, they can not be fully enforced as long as they admit of constant quibbling as to the meaning of common words in our language. No doubt these objections will be removed, for it is a time of fuller awakening to the conscience of our civic value.

Clothing which has been exposed to such infectious diseases as diphtheria and smallpox, is now destroyed or duly disinfected, at least theoretically. This is not the case with clothing, either second-hand or new clothing, made in the sweatshops, where we know tuberculosis is rampant. Clothing thus serves as a means for the spread of infectious diseases. This can be stopped by requiring new clothing to be thoroughly disinfected before allowing it on the market, or, better, by applying the old Mosaic law enjoining the strictest cleanliness. Moses really anticipated our modern sanitary laws, for cleanliness is the beginning and the end. The existence of sweatshops is one very dark blot upon the page of our vaunted civilization.

The problems of city sanitation no doubt can all be solved with unlimited means and unrestricted legal power and the machinery for exercising it. Practically, however, the economics involved affect the situation. Successful manufacturing enterprises usually begin with experimental plants and furthermore keep them constantly in operation afterwards as an economic means of improving their efficiency. Some cities have appreciated this principle as shown in the Lawrence Experiment Station at Boston. But these things cost money and all know what influence ''taxes'' are made to play in all political campaigns. It appears not unfrequently that the excuse is offered on the part of budget committees, or similar regulating bodies, for not apportioning appropriations, ''we can not afford research.'' No political party could leave a more lasting monument, if it went out of existence, than the establishment of the principle that a great city can not afford not to establish experimental stations. If the leaks are stopped, there will be plenty left not

only to establish bureaus of investigation, but some to save as well.

A progressive manufacturer does not hesitate long in substituting more efficient machinery. He also knows that his people are more efficient and happier in good sanitary surroundings. So, even if the leaks are stopped and the cost of running mounts up, the community is the better able to bear the burden and does it cheerfully. The average American doesn't mind paying a suitable price for a satisfactory article; in fact, of late he has become somewhat accustomed to paying a little more than he should.

The complications arising from the growth of cities call not only for "the employment of well-trained, tactful, honest, energetic and fearless health officials," but also lays a responsibility upon all forms of educational activity to bring about a "better appreciation by the people at large, of what is conducive and what a menace to public health," and individual safety.

In regard to health officials, I can not refrain from expressing an opinion bearing upon the organization of a health department. In the first place the head of the health department should be an expert sanitarian and not merely a doctor of medicine, whose training in sanitation has been incidental. He should be a specialist in sanitation with the background of a medical doctor. Furthermore, the numerous details, especially financial, should not be thrown upon the head any more than the captain of a warship should look after the details of the ship's larder. The chief needs every particle of his well-trained brain and energy to deal with the great problems of the city's health. He should be provided with a financial coadjutor—a man of absolute rectitude, and as well trained as himself, but along another line —a man who will see that the purchasing power of the city's money is equal to that of a private corporation. The terms of office of these directors, technical and financial, should be limited to the period of normal human efficiency, decent pension provisions being made for them when that period shall have ended. They would thus be unhampered by any political, religious or social associations, in the conduct of the department. I recognize that such a proposition is somewhat radical—in fact in direct opposition to the opinion of some—and sounds a bit utopian, but I am glad to say that my confidence in my fellow man is such that I am willing to give such large powers to him. Our democratic government breeds men worthy of such confidence; if it does not, then it is a failure, and we are not willing to acknowledge or to accept that verdict.

CHARLES BASKERVILLE
COLLEGE OF THE CITY OF NEW YORK

SCIENTIFIC NOTES AND NEWS

AT the Minneapolis meeting of the American Association for the Advancement of Science, Dr. Charles E. Bessey, professor of botany and dean at the University of Nebraska, was elected president for the meeting to be held at Washington, beginning on December 27, 1911. It is planned to hold the meeting of 1912 at Cleveland. The meeting of the association and of the affiliated societies at Minneapolis was in every way successful. The registration of members of the association was 663, which represents an attendance of scientific men about twice as large. Owing to the distant place of meeting, it is necessary to wait until next week for the publication of the report of the general secretary and the addresses of the vice-presidents.

PROFESSOR ALEXANDER SMITH, University of Chicago, was elected president of the American Chemical Society at the Minneapolis meeting.

AT the meeting at Ithaca the following were elected as officers for 1911 of the American

Society of Naturalists: *President,* Professor H. S. Jennings, Johns Hopkins University; *Vice-president,* Dr. Geo. H. Shull, Carnegie Institution; *Treasurer,* Professor E. M. East, Bussey Institute; *Secretary,* Professor Chas. R. Stockard, Cornell Medical School; *additional members of the Executive Committee,* Professor W. L. Tower, University of Chicago, and Dr. B. M. Davis, Cambridge, Mass.

Professor W. G. Farlow, of Harvard University, was elected president of the Botanical Society of America at the meeting held last week at Minneapolis.

Dr. W. H. Dall, of the U. S. National Museum, was elected president of the American Paleontological Society at its recent Pittsburgh meeting.

The American Psychological Association at the Minneapolis meeting elected Professor C. E. Seashore, State University of Iowa, as president, and Professor Walter V. Bingham, Dartmouth College, as secretary.

Professor Frederick J. E. Woodbridge, professor of philosophy at Columbia University, has been elected president of the American Philosophical Association and Professor Walter T. Marvin, of Rutgers College, vice-president.

M. Armand Gautier has been elected president of the Paris Academy of Sciences for 1911. M. Lippmann becomes vice-president.

Dr. Lewis Boss, director of the Dudley Observatory at Albany, and Dr. Frederick Küstner, professor of astronomy at Bonn, have been elected corresponding members of the Berlin Academy of Sciences.

Dr. Richard Hertwig, professor of zoology in the University of Munich, has been made knight of the Maximilian order for art and science.

Professor J. H. Poynting, F.R.S., has been elected a foreign fellow in the Reale Accademia dei Lincei.

Mr. Sydney Chapman, M.Sc., of the University of Manchester, has been appointed a chief assistant in the Royal Observatory, Greenwich.

M. Ernest Fourneau has been elected director of a newly-established laboratory for researches in the chemistry of therapeutics in the Pasteur Institute, Paris.

Dr. Karl Neumann, professor of mathematics in the University of Leipzig, has retired.

Dr. John L. Todd, associate professor of parasitology at McGill University, will join the expedition sent by the Liverpool School of Medicine to Gambia, Africa, for the study of tropical diseases.

The movement set on foot by the Liverpool School of Tropical Medicine in commemoration of the work of Dr. J. E. Dutton, who lost his life on the Congo through contracting spirillum fever while on the twelfth research expedition of the school in 1905, has now been completed. The school has been able to offer Liverpool University £10,000 for the establishment of a chair in tropical entomology. At a meeting of the council of the university it was resolved gratefully to accept the offer.

At the New York Academy of Medicine meeting, December 15, the president, Dr. John A. Wyeth, gave a brief memorial address on the late Dr. Robert Koch, honorary fellow of the academy. Dr. S. Adolphus Knopf, who was a student under Dr. Koch, presented a portrait of Dr. Koch.

Dr. Willis G. MacDonald, professor of surgery in Albany Medical College, died on December 30 at the age of forty-seven years.

Dr. Franz König, formerly professor of surgery in Göttingen and Berlin and later head of the surgical Hospital of the Charité, Berlin, known for his work in the treatment of articular tuberculosis, died on December 12, at the age of seventy-eight years.

The death is announced of Dr. A. Kraemer, formerly professor of agriculture in the Zurich Polytechnic Institute, at the age of seventy-eight years.

The Elizabeth Thompson Science Fund was established by Mrs. Elizabeth Thompson, of Stamford, Conn., "for the advancement and prosecution of scientific research in its broadest sense." The income from this

fund is now available, and the trustees desire to receive applications for appropriations in aid of scientific work. The trustees are disinclined, for the present, to make any grant to meet ordinary expenses of living or to purchase instruments, such as are found commonly in laboratories. Decided preference will be given to applications for small amounts, and grants exceeding $300 will be made only under very exceptional circumstances. Applications for assistance from this fund, in order to receive consideration, *must be accompanied by full information,* especially in regard to the following points: (1) Precise amount required. Applicants are reminded that one dollar is approximately equivalent to four English shillings, four German Marks, five French francs, or five Italian lire. (2) Exact nature of the investigation proposed. (3) Conditions under which the research is to be prosecuted. (4) Manner in which the appropriation asked for is to be expended. All applications should reach, before February 1, 1911, the secretary of the board of trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass., U. S. A.

IT is stated in *Nature* that a prize of 100,000 francs is to be awarded to the inventor of a practical apparatus which will make it possible to save the crews of wrecked submarines, enabling them to regain the surface uninjured. The French minister of marine is able to offer the prize, as he has received an anonymous gift from a French lady for the purpose.

MR. THOMAS LUPTON, of Great Britain, solicitor to the Royal Institution, who died on October 30 last, aged 90 years, left £10,000 for the general purposes of that institution.

THE department of zoology and entomology of the Ohio State University has recently received the gift of a fine collection of Lepidoptera from Mrs. Catherine Tallant, of Richmond, Indiana. The collection was made by Mr. W. N. Tallant and contains mainly species occurring in central Ohio, especially at Columbus, but has also a number of species from different parts of the United States, and also some fine samples of species occurring in South America, Japan, China, India, Ceylon and Africa. The collection contains about 10,000 specimens in most excellent condition, very beautifully mounted, and many of the species contain very full series, showing variations, etc., which will make them of special value for scientific study. They are, for the most part, carefully identified and will be kept under the name of the "Tallant Collection." Taken with the other collections in Lepidoptera, the collection of Odonata left by Professor Kellicott, and those in various groups which have been accumulated by the efforts of the members of the department, the university is now provided with excellent series of insects, including representatives in all the different orders. The total number of specimens in all orders probably approaches close to 100,000.

THE expedition sent by the Carnegie Institution of Washington for geologic exploration in China in 1903–04, in charge of Dr. Bailey Willis, secured a number of large negatives of Chinese scenes representing the scenery; the geological conditions, particularly of loess landscapes, and also of Chinese buildings, monuments and people. The route of the expedition through the provinces of Chili, Shansi and Shensi, led through the loess district and some remote mountain regions of great interest and scenic beauty. This collection of photographs has been placed on file with the Smithsonian Institution and copies may be had for educational purposes by application to the secretary of the institution and payment of costs.

TRINITY COLLEGE, Hartford, Conn., has retained the Ralph B. Carter Company, of 50 Church Street, New York, to install a circulation sea-water system in the five marine tanks in Boardman Hall, similar to the one which they placed in the aquaria house at Princeton. Hard rubber piping and valves are used to convey the sea-water from cedarwood tanks, and return the water to the reservoir, also of cedar, by way of a sand filter. The water will pass through a bronze motor-driven compressor

into an air reservoir where aeration will take place and air and water together will be pumped through the pipes to the aquaria, thus differing from the Princeton system where a column of air is forced against the water in the pipes and the water does not enter the pump. The tanks may be converted immediately into fresh-water tanks, whenever this is desired.

The subjects and dates of the lectures to be delivered before Easter at the Friday evening meetings of the Royal Institution of Great Britain are as follows: January 20, Sir J. Dewar, "Chemical Change at Low Temperatures"; January 27, Professor W. H. Bragg, "Radioactivity as a Kinetic Theory of a Fourth State of Matter"; February 3, Mr. A. E. Shipley, "Grouse Disease"; February 10, Mr. S. Colvin, "Stevenson"; February 17, Professor H. E. Armstrong, "Digestive Activity"; February 24, Professor Jean Perrin, "Mouvement Brownien et Realité Moleculaire" (in French); March 3, Professor Karl Pearson, "The Inadequacy of Causation in Modern Science"; March 17, Mr. J. H. Balfour-Browne, K.C., "Water Supply"; March 24, Sir D. Gill, "The Sidereal Universe"; March 31, Professor H. S. Hele-Shaw, "Traveling at High Speeds on the Surface of the Earth and Above It"; April 7, Sir J. J. Thomson, "A New Method of Chemical Analysis." A course of Christmas lectures on "Sound: Musical and Non-musical" will be given by Professor Silvanus P. Thompson in the afternoons of December 29 and 31 and January 3, 5, 7 and 10.

UNIVERSITY AND EDUCATIONAL NEWS

Commemorative exercises in celebration of the completion of the first twenty-five years of the work of the Carnegie Laboratory of New York University, and of the opening of the Carnegie laboratory extension, will be held on the afternoon of January 10. Addresses will be made by Mr. Andrew Carnegie, Dr. William H. Welch, Dr. Henry S. Pritchett, Dr. Hermann M. Biggs and Mr. Jerome D. Greene.

The fifth congress of the American School Hygiene Association will be held at the Academy of Medicine in New York City on the second, third and fourth of February. A tentative program includes papers by Lyman A. Best, William H. Allen, Dr. S. W. Newmayer, Dr. Myles Standish, Dr. Woods Hutchinson, Dr. Thomas F. Harrington, Dr. W. S. Cornell, W. E. Watt, Dr. Arthur T. Cabot, Dr. Luther H. Gulick, Leonard P. Ayres, Dr. Helen MacMurchy, Professor William H. Burnham and Dr. John J. Croner.

During the thanksgiving recess at the University of Illinois, a party of electrical engineering students and of architectural students took a trip of inspection to various points in the vicinity which are of especial interest to engineers. The electrical students visited the Quarry Street power station, the steel works at Gary and the works of the Allis-Chalmers Company at Milwaukee. The architectural students visited various buildings in Chicago and inspected the plant of the Northwestern Terra Cotta and Tile Company.

Professor C. S. Sherrington, F.R.S., of Liverpool, and Dr. William Bulloch, director of the Bacteriological Laboratory of the London Hospital Medical School, were appointed members of the advisory board of the Beit Memorial Fellowships for Medical Research. The next election of fellows will be held in December, 1911. The last date for receiving applications from the colonies and abroad is October 1, 1911, from Great Britain and Ireland November 1, 1911. Communications should be addressed to the Hon. Secretary, Beit Memorial Fellowships for Medical Research, 35, Clarges Street, London, W.

In behalf of a donor who withholds his name, Mr. George L. Rives, chairman of the trustees of Columbia University, and Mr. Robert W. DeForest, president of the board of managers of the Presbyterian Hospital, announce that $1,300,000 has been pledged for the perfection of an affiliation between the hospital and the College of Physicians and Surgeons of the University. The gift comes through Mr. Edward S. Harkness, of New York and Cleveland, who gives $300,000 for a surgical pavilion and a laboratory for research work. Several conditions are named, the two

most important being: (1) That the hospital shall admit to the wards students of the medical schools to the extent and in the manner permitted by the most approved practise. (2) That the educational institution concerned may make nominations to all positions on the hospital staff, medical, surgical and special.

THE completion of the fund of $750,000 for the Johns Hopkins University is announced. This insures the payment to the fund of a further $250,000 offered conditionally in February of last year by the General Education Board.

BY the will of Mrs. Martin Kellogg, Yale University receives a bequest of $50,000 from the estate of the late Martin Kellogg, who was formerly president of the University of California.

MR. H. J. PRIESTLEY, M.A., assistant lecturer in mathematics at the University of Manchester, has been appointed professor of mathematics and physics in the newly-constituted University of Queensland.

DISCUSSION AND CORRESPONDENCE

SYMBOLS IN ZOOLOGICAL NOMENCLATURE

PROFESSOR NEEDHAM'S proposal[1] of a plan for practical nomenclature deserves more attention than has yet been given it publicly. To be sure, our energetic friend Professor Cockerell has published a brief destructive critique[2] based on personal opinion as to what can be most easily retained by the memory, and on sentiment. As to the former, one might differ from him in individual cases, or might justly observe that memory is not the only factor involved in Professor Needham's proposal. So far as sentiment goes the incongruity and falsity of many names will make as good an argument on the other side of the question, while the colorless number adapts itself far better to changing interpretations with the progress of science than any word with its fixed relation to ideas. Nor can I believe that it is any part of scientific nomenclature to "call up pleasanter [philological] thoughts." It certainly is worth while to have the great names of the past brought to our attention, but such men are in our thoughts constantly not because they have named a few species more or less, but because they have made real contributions to the progress of science. And what shall one say of the constant burdensome recurrence in systematic work of the names of the unknown, of those who have torn down the good work of their associates and have left the roadway of science rocky with synonyms, errors in determination and description, false statements and careless records, misspellings and misquotations. It is these rocks in the way that make the pilgrim to-day toil wearily up the height more conscious of the obstacles such men have left than of the substantial roadway the real workers have constructed.

But to my mind all of this fails to reach the heart of the problem or in any way to affect the fundamental contentions urged by Professor Needham. For this reason I am anxious to aid if possible in directing attention to the real questions at issue and the probable lines for their successful solution.

The history of all science shows intercurrent tendencies towards simplification and complication. The data already established are reduced to greater simplicity in expression and the new relations that are demonstrated involve them at the same time in constantly increasing complexity. That simplification in terminology is a real tendency is apparent to every one who studies the history of zoology and compares the long and involved circumlocutions of early writers with the more precise designations of to-day. Hand in hand with this simplification in form goes a movement towards standardization in use and meaning which finds its expression in modern terminology. The term becomes more precise as it becomes more limited and because its use is limited.

The history of zoology does not in this respect differ from the past of other sciences and yet the comparison shows that some other sciences have progressed further along this

[1] SCIENCE, September 2, 1910, pp. 295–300.
[2] SCIENCE, September 30, 1910, p. 428.

line of development than zoology has yet gone. Such a simplification by the employment of symbols has become thoroughly incorporated into the substance of some sciences and is proposed for introduction into others. An examination of these conditions shows some interesting and in my opinion valuable considerations for this discussion.

Probably because numbers were the basis of mathematics the origin of the science is often said to date from the invention of numbers. But even with that it may be noted that the symbols were not in all cases identical and in one system Roman letters were employed, whereas another used Arabic numerals for the same general purpose. Nor can one well doubt the superiority of the Arabic notation over the Roman even if sentimental grounds lead one to prefer the classical to the Moorish civilization in laws, government or other social conditions. Probably mathematics represents the most highly developed of all sciences and the modern mathematician is not deterred from the use of symbols by any danger of misprinting, confusion, error of memory or other similar objection, real though each of them is in this case also.

The case of chemistry is even more enlightening because the introduction and universal use of symbols is of comparatively recent date. One does not have to seek far to find arguments against the use of symbols for the designation of chemical elements which read strikingly like the objections of Professor Cockerell to the plan which Professor Needham advocates. Errors do occur in chemical literature, proofreading is far more difficult because of the numerous easily confused symbols in use to-day and the abandonment of those quaint old names which disclose some of the secrets of the alchemist and of the mystic age of chemistry, was a real sentimental loss. Yet I doubt if any one could now be found who would seriously contend that we should return to the presymbolic days even if it were possible to express modern chemical work in ancient form. Simplification through the use of symbols has come to stay in chemistry as in mathematics.

It is no argument whatever against the general proposal to introduce some such system into biological sciences to say that the latter are less precise, that their units are more numerous and more complicated than those of mathematics or chemistry. If the problem had been as simple it would have been solved as easily as were the others. The delay in reaching any solution indicates the existence of difficulties but does not afford any basis for rejecting efforts to solve the problem or for characterizing the problem as insoluble along this line. The greater complications of biology make its development slower because they demand for their consideration and analysis a more highly organized general scientific foundation and a more highly trained body of scientific workers. The solution may not come in our time, but it will surely come some day.

But other sciences also are looking for possibilities of simplifying and of standardizing their forms of expression in the manner so successfully adopted by chemistry. One example of most recent date may suffice to show the tendency. This is taken from what may be regarded as the most recent addition to the circle of sciences, geography. In an address before the Geographical Section of the British Association at Sheffield this year, the brilliant young Oxford geographer, A. J. Herbertson,[1] dwells upon this matter, saying in introduction, "I have long thought that we shall be driven to some notation analogous to that of the chemists." After suggesting a possible scheme for consideration he adds: "This is the roughest suggestion, but it shows how we could. . . . No doubt there would be many discussions. . . . But after all these discussions would be more profitable than quarrels as to which descriptive term, or place name or local usage should be adopted to distinguish it."

With only minor changes in phraseology this description of dangers and profitless discussions which geography should avoid portrays actual conditions in the zoological field.

[1] Science, November 25, 1910, p. 745.

Zoological nomenclature has received heroic treatment during the past ten or fifteen years. The difficulties which had arisen in the natural course of development under the Linnæan system had led to numerous isolated efforts for their correction until finally an attempt has been made to remedy the evils under the control of a central organization which has been so firmly established by zoologists as to be at present beyond their control and swayed by laws alone. Yet even such an autocratic and omnipotent body has not succeeded in doing more than increasing the difficulties of the situation. It really seems as if the problem requires more radical measures for its solution. The present plan of organization is incapable of coping with the complications which have arisen in the rapid expansion of biological knowledge during the last half century. Personally, I am convinced that the Linnæan system offers no probability of meeting the situation. Of this there may be some question, but there is abundant evidence to show that the existing zoological nomenclature is meeting with wide-spread criticism and does not command the support to be expected of so fundamental a system. Indirect but weighty evidence of this may be found in the fact that the use of common names is increasing and that a larger proportion of biological workers than ever before are avowedly indifferent to the use of technically correct scientific names.

Present conditions are denominated unsatisfactory by able men in many places and in diverse special lines of work in the general field. The most important general criticisms of the existing conditions may be stated briefly as follows:

1. *Lack of Stability.*—Present nomenclature by law depends upon the accuracy of the past and upon the completeness of our knowledge concerning its work. At any time demonstration of an error in statement or of an omission in the references to previous work may overturn a name or series of names and throw all the literature on the group into confusion. New laws and new rulings are made with the same result, for in our effort to out-Herod Herod we go further than the law, that most conservative of professions, has ever gone. We make and enforce *ex post facto* laws which upset the established practise of a century.

2. *Overemphasis upon Trivial Features.*—Page-long discussions recur constantly on the acceptance of *A*'s name or *B*'s name and both sides argue with apparent justice and at interminable length. Articles follow hard on each other's heels dealing exclusively with the spelling of names: Shall it be *somum* or *soma?* Shall one write *nni* or *nii?* And the questions are never decided, for even the high priests of the movement differ in their views and their practises, and the great majority of biological workers pay little attention to the strife because they feel the issues are trivial. Now the real meat of the question is the thing and not its name. And all this energy devoted to a study of the animal itself would yield much of value to science. The workman does not care whether *A* or *B* gives him his tools; he wants a tool and wants it sharp, because he wants to do work with it. He is rightly impatient of so much hair splitting to so little purpose, but he does look forward to the time when in some way this energy may be diverted into productive channels.

3. *Exaltation of Error.*—If a tyro commits an error, if a neophyte goes astray or makes a foolish move, we are accustomed in science otherwise to consign his work to kindly oblivion, but in nomenclature this may not be. The skeleton of his misbirth must be hung in the public hall of the systematic museum, to dangle its misshapen bones before both students and visitors for all time. There is no other option possible to-day under the laws of nomenclature. A mistake once incorporated in the literature of biology must forever remain there, even though apparent to the man of education at a glance. The most conservative theologian would hesitate to support such an inflexible demand for the maintenance of the past, errors and all. And the very fact that able and zealous advocates of present nomenclature contend there is no other way under the present system compels

the conclusion that this system is insufficient for the needs of a science which seeks to eliminate error and to establish truth.

4. *Multiplication of Complications.*—No one can doubt that the complexity of zoological nomenclature has increased enormously within very recent years. Furthermore, no one will deny that much of this increase is due to the expansion in our knowledge of the biological world and its interrelations. This natural growth in complexity is as welcome as it is inevitable, but if real progress is to be achieved it must be accompanied by a perfection and simplification of the machinery of control and of investigation in which a prominent element is the systematic nomenclature of the subject. Now there is reason to believe that the system in use has become unnecessarily intricate, that its parts are involved by the nature of the case in ways such as to create grave difficulties for the ordinary worker. These difficulties are certainly greater to-day than they were twenty years ago and this result has been produced by the changes and complications incident to the new legislation in the subject during very recent years. Such changes may have been wise and necessary from the legal standpoint, they may be perfectly in line with the natural development of the present system. But that only strengthens my contention that zoology must look for a better system, must seek a way of escape along an entirely new line. I am aware also that these changes meet the approval of those who have devoted much time to the study of taxonomy and that they do not regard the complications as hindrances to progress. No doubt from their point of view this is true, but there is another aspect of the question which deserves careful examination.

To the skilled systematist, thoroughly acquainted with his own groups, confident, accurate, critical, these difficulties constitute intellectual stimuli rather than stumbling blocks. He follows the changes in names with delight in the history of the science that they portray. Outside his own corner of the field he often does not care to go, or if he wanders it is not so far afield that he is at a loss to find the necessary help to keep him in the path. But to the general worker this constant shifting constitutes a real burden that retards his progress and reduces the efficiency of his work. This is, however, not the most serious feature of the case.

To the general public even in the educated world scientific names will perhaps remain as they unfortunately now are regarded, "beyond the powers of ordinary mortals," and birds and beasts, insects and shells, will continue to be called by their popular names because the latter are not only simpler, but also do not change from day to day. But to the neophyte who hesitates on the threshold of the science, uncertain whether he shall enter or who later pauses before he essays to mount to higher levels in the fields of our elysium, the difficulties which our present nomenclature sets in his path are at best disheartening. He would read of the great work of the past and know its relation with that of the present. But you must tell him that *Amphioxus* is not such but *Branchiostoma,* that *Holothuria* is not an echinoderm, that even *Amœba* to-day is *Chaos!*—and a multitude more changes which confuse his mind and dull his enthusiasm. He wants to study life, not letters. But at the very start of his work he is forced to violate that canon of accuracy which is the foundation of science or to assume a burden that wastes his energy in a vain effort to keep up with the latest revisions of nomenclature. Like Sindbad the Sailor, he struggles along with this Old Man of the Sea on his back until he decides to be quit of his burden, and without openly indicating his purpose, contrives to wander off with the morphologists or biologists, leaving nomenclature behind.

Now these multifarious complications are the necessary and logical consequences of the system of laws which zoologists themselves have adopted and as such are unavoidable in the opinion of the expert legalist. The natural reply to such a dictum is then let us follow the promptings of our scientific consciences and devise some better system. Why should we not find a simpler and effective

method of designation in a system of symbols such as other sciences have found? I am not in sympathy with those who look for relief in a laxer more open administration of the present system. Such a line of action does not seem to me likely to prove either effective or legitimate.

This rigor in systematic nomenclature is a natural reaction from the free and easy methods which have prevailed in the past. Biological science even to-day publishes loose, inaccurate statements in research contributions which would be laughed out of court in physics or chemistry, to say nothing of mathematics or astronomy. It is necessary that some reform be undertaken, that our branch of science approach more closely to the precision in observation and experiment, in record and discussion that characterizes older sciences. The natural lack of fixity in biological phenomena has been utilized to excuse a lack of precision in method and investigation which must be corrected. One effort to reach a more justifiable basis is seen in the recent development of statistical work, and in the publication of definite numerical results rather than merely generalizations in connection with experimental work, in the effort to control more accurately and state more precisely the conditions of such experimentation and to analyze more closely the results obtained. In such lines zoology has achieved wonderful progress in the last twenty years or even less.

The same influences will lead to a reform of our system and, following the lead of other sciences, such a reform is likely to be accompanied by the simplification which is associated with the utilization of symbols. The far-seeing biologist should be on the watch for a plan which promises some measure of success in this line, he should welcome all reasonable attempts at the solution of the problem. Of course he will not reject any and all systems because they are new departures; and yet he should not fail to subject each to careful consideration because it may seem to be inadequate or only partially worked out. Out of such careful discussion will come the longed-for result in a workable form. But the system itself will represent contributions from many sources.

I confess that Professor Needham's plan seems to me at most only a partial solution of the problem. Even as such it may prove to be of great value and it is to be hoped that biological workers may be willing to try it on various groups in diverse portions of the field and may then report on their results. Better still if it could be subjected to a trial by some recognized society or institution with a view to testing thoroughly its character. It would be valuable to compare it carefully with the much more complex system proposed some years ago by Tornier[4] which seems to have attracted no attention, although it was a most ingenious and original means of formulating a symbolism for zoological nomenclature. While this system was much more complex and covered not only species as proposed by Professor Needham's plan, but also genera, and indicated the precise place in class, order and family occupied by each genus and species, yet apparently the symbol used for a given form would not be permanent and independent of changing views regarding the position and relationship of genera and higher groups. This lack of stability would be a serious, if not fatal, objection to the introduction of a new system planned to correct precisely the same defect in the old.

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BOTANICAL EVIDENCE OF COASTAL SUBSIDENCE

IN a recent article[1] Professor D. W. Johnson calls attention to certain conditions at Scituate, Mass., which are there responsible for a fictitious appearance of coastal subsidence. During the "Portland Storm" of 1898 the bar was broken which at that locality almost separates the North River marshes and bay from the ocean, with the result that the high tide level on the marshes is now from one to several feet higher than it was then.

[4] *Zool. Anz.*, Vol. 21, p. 575, October 24, 1898.

[1] SCIENCE, N. S., XXXII., 1910, p. 721.

Trees surrounding the marsh have been killed and are now standing among salt marsh grasses. Since breaches in bars, widening of tidal inlets and other shore-line changes may cause local fluctuations of a number of feet in the high-tide surface, Professor Johnson hastily concludes that no evidence of recent subsidence on the New England coast thus far presented can be considered satisfactory.

It is the mean sea level, rather than the irregular and changeable high-tide surface, which is most important in discussions of coastal subsidence. Below mean sea level the salt-marsh builders, *Spartina glabra* and *Spartina patens,* can not live. As a matter of fact *Spartina patens,* by far the more important of the two plants, seems to occur in significant amount only within a vertical range of about two feet. It builds its turf up to mean high-tide level. Above this level it is for the most part replaced by other plants, notably by *Juncus Gerardi* and various species of *Scirpus.* We may, therefore, regard any thickness of *Spartina patens* turf greater than two feet as a measure of change in high-tide level. If such turf extends to mean sea level, or below it, the evidence that subsidence has taken place is indubitable. If a deep turf is of uniform texture throughout, a strong presumption is created that subsidence has continued uniformly to the present time. *Spartina patens* turf lies below mean sea level at many places in the vicinity of Boston, as, for example, near the mouth of the Saugus River, where it forms a homogeneous stratum to a depth more than ten feet below high-tide level. The geological significance of turf formation by *Spartina patens* has been pointed out by Professor C. A. Davis,[2] of the Bureau of Mines. He presents substantial evidence that coastal subsidence is now going on—evidence to which the hypothesis of a fluctuating high-tide level has no possible application.

Aside from the value of the salt marsh deposits themselves as indicating subsidence, there is still another type of botanical evidence which Professor Johnson should not so lightly have disregarded. In certain cases where fresh water peat is found below mean sea level, in obviously undisturbed relationship to the substratum, whether or not the deposits have ever been invaded by the sea, we have incontrovertible evidence of subsidence. The full argument in support of this statement has been published elsewhere,[3] but may be briefly reviewed here.

Peat deposits are of two main types, depending upon the relation of the water table to the ground surface in the depression in which they are formed. In the first type the depression contains a pond or other body of water, so that the peat is derived from aquatic plants and from the surface of the water, through the agency of mat-forming plants. If the water in such a depression were fresh, a mat might be formed at or slightly above sea level, and fresh-water peat of this type would then be laid down below sea level. If the ocean should break into such a bog it is conceivable that the mat might settle considerably and then be covered by salt-marsh deposits. Such a condition I have never seen.

The second type of peat deposit is built up from the ground by successive elevations of the water table, as we know from the character of the plant remains which it contains. At every stage of growth its surface has very nearly coincided with the ground water level. Since in coastal Massachusetts the water table is never lower than sea level, a bog of this type, if its bottom is lower than mean sea level, must of necessity be interpreted as a record of subsidence.

There is a locality at Quamquisset Harbor, on the coast of Buzzard's Bay, where the sea has cut into a *Chamæcyparis* bog. At the water's edge a sounding showed uniform peat, containing *Chamæcyparis* wood, to a depth of fourteen feet below mean sea level. The sand bottom of the deposit had not been disturbed by under-cutting. At the point where this sounding was made, there were salt-marsh deposits in a thin layer overlying the peat,

[2] "Salt Marsh Formation near Boston and its Geological Significance," *Economic Geology,* V., 1910, p. 623.

[3] "The Submarine Chamæcyparis Bog at Woods Hole, Mass.," *Rhodora,* XI., 1909, p. 221.

but further inland the *Chamæcyparis-Sphagnum* peat was still forming, at an elevation perhaps three feet above high-tide level, and soundings showed that the deposit was uniform from top to bottom. Within a very few feet of the seaward edge of the marsh there are still two or three small stumps which project several inches above the *Spartina patens* turf which has grown up around them. These constitute a strong argument that subsidence is still going on. If there had been no subsidence for 3,000 years, as Professor Johnson thinks likely,[4] these little stumps would surely have rotted away by this time!

The Coast and Geodetic Survey has furnished data regarding the tides in Quamquisset Harbor. Spring high water is 2.4 feet above mean sea level. Mean high water is 2.0 feet above mean sea level. The highest tides observed were 3.0 feet above mean sea level. These tides at Quamquisset are so low that Professor Johnson's hypothesis of a fluctuating high-tide level can not possibly be invoked in explanation of the submarine peat beds.

After examining one locality where salt-marsh plants have invaded a fresh-water vegetation under conditions certainly far from typical, and where all of the fresh-water remains are found at extreme high tide, Professor Johnson has ventured to characterize all the evidence which has been offered for recent subsidence as inconclusive. As a matter of fact his hypothesis has no bearing whatever on most of the evidence which has been offered.

H. H. BARTLETT

BETHESDA, MD.

FACULTY OR PRESIDENT?

THE discussion of the merits of control by the faculty or by the president in any educational institution, which has been presented from time to time in SCIENCE, was continued by some references in Professor Cattell's article in the issue for November 11, and by a short paragraph in the abstract of President Schurman's annual report in the following number. There is still another angle from which the matter may be viewed.

The student body in a college, or university, is a comparatively constant quantity. The great majority of students spend the four years from about eighteen to twenty-two in the institution of their choice. The average age of the student body, taken as a whole, would, therefore, be slightly under twenty, owing to the somewhat greater numbers in the freshman and sophomore classes. Whatever fluctuations there might be from year to year, in consequence of an exceptionally large or surprisingly small entering class, or because an unusually large number from the upper classes turned to professional work before graduation, they would be within very narrow limits, so narrow, indeed, that the entire body of students might be regarded as an individual not quite twenty or just over twenty years of age. The same would be true of a university with the various professional schools and the liberal arts or undergraduate department, although the average would probably be three or four years higher. The student body itself, none the less, would be comparatively stable.

If we turn our attention to the faculty, we find another fairly constant quantity. Since the retiring age is somewhere about sixty-five or seventy—it might be a little over or a little under—and since the youngest instructors are just out of college, the average age of a faculty would be somewhere between forty and forty-five, as a rough estimate. If there should be an unusually large number of young instructors, or an extra large number of elderly professors, then the average age would be lowered or raised correspondingly, but in either case it would not be far from the age mentioned above, and from year to year the fluctuations would be within rather narrow limits, so that there would be a fairly stable body to exercise control of whatever sort. In those institutions in which the youngest instructors have practically no voice in the administration, the average age would be raised, but the faculty would retain its characteristic of a constant quantity.

When the problem is presented in this way,

[4] SCIENCE, N. S., XXXII., 1910, p. 709.

we have two constants sustaining a constant relation to each other. They are not so far apart, too, in the matter of age, but that each may understand the other. The relation is essentially that of parent and child. The student body may be regarded as of a healthily radical temper of mind, and the faculty as healthily conservative. Sociologists maintain that both radicals and conservatives need to be united in a community, with the center of gravity slightly on the radical side, if that community is to be healthily progressive. With the faculty and students viewed as above, the conditions are right for a sanely progressive institution, since we may, perhaps, assume that the larger size of the student body would give the desired overplus of radicalness. At any rate, there would be a steadiness of control and of purpose, and a sufficiency of sympathy to insure hearty cooperation and splendid scholarly results.

When, however, we consider the matter from the side of the one-man power, whether that man be president, or some other official with the bit in his teeth, the conditions do not seem to be so favorable for desirable results. If the president be young—we will say thirty years of age, as sometimes happens—the center of gravity is too much upon the radical side; when the same man gets to be sixty-five or seventy, provided he stays that long, or has an elderly successor, the balance shifts too much in the other direction. It is true, of course, that there are conservative young men and progressive old men, but, none the less, the fluctuations in the age of the controlling official constitute a variable more likely than not to be a disturbing factor in the otherwise constant and harmonious relation between faculty and students. In the case of the elderly man being in supreme control, the relation of parent to child will be superseded by that of grandparent to grandchild, with consequent ready indulgence or excessive rigor. The latter is, perhaps, the more likely, since the nervous strain develops irritability and the exercise of power breeds arbitrariness.

When the problem is viewed from this angle, the wise policy would seem to be to have faculty control in an educational institution, rather than that any one man should reign supreme.

Gregory D. Walcott
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The Matter of University Fellowships

To the Editor of Science: The address of Dr. Jordan as retiring president of the American Association for the Advancement of Science, printed in your issue for December 30, contains many things that will appeal to every one as both true and timely; there is the more reason to regret that some things are said against which, I think, protest should be made. I do not believe it is true, as he seems to think, that the system of university fellowships is a powerful influence working against our best university ideals. Dr. Jordan seems to me to have lost sight of some very important facts when he stigmatizes the fellowship system as one "whereby men are hired to work under men they do not care for and along lines which lead not to the truth they love, but to a degree and a career." I am sure he does injustice when he asserts that "The embryo professor asks for his training not the man of genius who will make him over after his kind, but the university which will pay his expenses while he goes on to qualify for an instructor's position."

All will admit that the fellowship system has not always been wisely administered; that evils have crept into the practise of some institutions; that these ought to be (I think can be) corrected. We have all had experience of the man whose letter expresses a desire to work at our particular university and inquires, "What inducements can you offer me to come?" Undeniably, universities are themselves responsible in some measure for making possible such an attitude; but it would seem that only a particularly unlucky experience could make one regard this as typical of the graduate student in general.

Dr. Jordan's ideal university is one where advanced students are "gathered around a man they love, and from whose methods and

enthusiasm the young men go away to be like centers of enthusiasm for others." It is a high and noble ideal, and one towards which we are all most heartily ready to strive; but it is rather difficult to follow the logic of the conclusion that a fellowship system tends to destroy this ideal. It would be invidious to refer to particular men or universities had not Dr. Jordan himself set the example by naming, among others, four eminent teachers at one university who exemplify the ideal he has in mind. It is entirely true that these men drew students about them by the force of their ability and personality; but is it not also true that the university which placed them on its faculty did more than any other American university had previously done, by a system of wisely administered fellowships, to make such a gathering of students possible? It was my own good fortune to be one of those students, and I count it not only as a lasting honor but as the most important turning point in my life that appointment to a university fellowship enabled me to place myself under the inspiring influence of three of the four men whom Dr. Jordan names. I am sure that many others whose after lives have been given to teaching and research can bear like witness.

Dr. Jordan argues that it would be a difficult task to produce a Darwin, given the raw material, "if a fellowship of $500 had drawn him to a laboratory of some lesser plodder." But what does this prove if not the desirability of trying to widen the usefulness of the gifted teacher by making it easier to gather students of promise about him, and by helping such students as well as we can to the opportunity they seek? Happily for science, the circumstances of the youthful Darwin placed him beyond the need of such aid. He was free to "walk with Henslow" (to quote Dr. Jordan's own happy phrase); but had it been otherwise, who can estimate the value to the world of a helping hand to Darwin at a critical moment? We are sometimes told that fellowships tend to "pauperize" students. I do not believe it. All honor to the man who works his own way through college and university life. But the years of graduate study, perhaps above all others, ought to be a time of undisturbed and unremitting devotion to one's chosen work. The man whose ability and scholarship have proved him worthy to enjoy the privilege of at least one such year is in no danger of pauperization by the fellowship that gives him the opportunity. If he has been well chosen, his stipend is as well earned as that of any officer of the university. In my belief the university makes no better investment than the $500 a year that enables the man of talent, but of limited means, to carry on his work, and the example and influence of such men among the body of graduate students constitute one of the best assets of the university.

EDMUND B. WILSON
COLUMBIA UNIVERSITY,
January 1, 1911

SCIENTIFIC BOOKS

A Text-book of Botany for Colleges and Universities, by members of the botanical staff of the University of Chicago, JOHN MERLE COULTER, Ph.D., Professor of Plant Morphology; CHARLES REID BARNES, Ph.D., late Professor of Plant Physiology; HENRY CHANDLER COWLES, Ph.D., Professor Plant Ecology. Vol. I., Morphology and Physiology. New York, Cincinnati and Chicago, American Book Company. 8vo. Pp. viii + 484 + 12.

When Strasburger with his colleagues in the University of Bonn brought out a text-book of botany it was promptly named the "Bonn Text-book," following which precedent it has been suggested that the book before us should be named the "Chicago Text-book." And this American book promises to be a worthy rival of its German predecessor, which no doubt it will replace in many college and university classes. When complete, the book will include morphology, physiology and ecology, but for some reason not stated in the preface, only the first and second are now published. Probably that will follow before long, as some reference is made in the preface to "Part III." as at least partly prepared for publication.

The book is doubly interesting in that it

presents a certain amount of organized information in regard to a portion of the science of botany, and also that it gives us the result of ten years of experience in working out the method of undergraduate instruction in botany in one of the foremost botanical laboratories in the country. The authors here endeavor to present "the fundamental facts and principles of the science," and they hold that these should precede the work of most other subdivisions of botanical investigation. Thus they point out that "a study of the very important subject of plant pathology must presuppose the fundamentals of morphology and physiology; paleobotany is, in part, the application of morphology and ecology to fossil plants; and scientific plant breeding rests upon the foundations laid by morphology, physiology and ecology."

Here we have then an expression of the opinion of three eminent teachers as to what should be the "content" of botanical instruction, and its proper sequence, and it is that the structure of plants must be presented first in an orderly sequence from the lower to the higher forms, and that then the activities of plants must be considered, while the relations of plants to one another and to their physical environment may well come after form and function have been pretty fully considered. Then when these fundamental subjects have been pretty well mastered the student is ready to go forward into pathology, paleobotany, plant breeding, etc. The book is thus a contribution to botanical pedagogy. This aspect of the book is, we believe, most important at this time when some teachers have the notion that it makes little difference in what order the subdivisions of botany are taken up.

The morphological part plunges at once into a study of the Thallophytes, taking in succession (1) Myxomycetes, (2) Schizophytes, (3) Algæ, (4) Fungi, followed by Bryophytes, Pteridophytes and Spermatophytes, and a suggestive chapter entitled "Organic Evolution." The treatment is admirable, and the more than six hundred illustrations make this one of the most satisfactory morphological texts with which we are acquainted. The student who runs up through the vegetable kingdom in the sequence here given can not fail to secure a clear conception of its general plan, as well as of its probable mode of evolution.

The second part, devoted to Physiology, takes up the subject under five heads, viz., (I.) the material income of plants, (II.) the material outgo of plants, (III.) nutrition, (IV.) destructive metabolism, (V.) growth and movement. The treatment here is as satisfactory as in Part I., and as we read the lucid sentences we are reminded forcibly of the great loss suffered by botanical science through the death of Professor Barnes. We can not refrain from quoting a few sentences, both for the substance and as illustrating the forcible presentation.

> Transpiration, far from being a function of plants, is an unavoidable danger. That it is a danger, a real menace to life, is almost a matter of common observation. Millions of plants perish annually because the outgo of water is greater than the income. A loose soil and an exposed situation, sudden extreme evaporation due to a hot dry wind and a blazing sun, or prolonged drought, are causes of death too well known to farmers in some regions. Scarcely a plant escapes the loss of some parts by reason of shortage in the water supply; and in temperate regions, with the average rainfall (say 100 cm. annually), few plants attain the development of which they are capable with a larger water supply. The luxuriant weed of well-watered ground compared with the same weed, meager and dwarfed on the dry wayside, illustrates what a menace to life and vigor is the evaporation from plants.

It is greatly to be deplored that the facile hand that penned, and the active and original mind that framed such vigorous and lucid sentences are forever stilled, and that the work here so well begun must stop, or be carried forward by others. And who is there who can take the place of Barnes?

Charles E. Bessey
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Attention and Interest: A Study in Psychology and Education. By Felix Arnold, Ph.D. New York, The Macmillan Company.

In this volume Dr. Arnold presents the results of a study of the practical aspect of his problem. "The present essay on the psychology of Attention and Interest," says the writer, "is an attempt to classify and arrange the many facts that have been brought to light by numerous experiments in the psychological laboratories." In order to allow of the fullest review of such facts the conception of attention has been made as simple as possible; as developed in the Introduction, attention is the correlative of the development of an "object" in consciousness. The appearance of such an object of consciousness is not incidental to mental activity; in all developed consciousness it is its characteristic form. The problem of the essay is an inquiry into the history and values of this characteristic activity of mind. Attention and interest are therefore considered in their intrinsic relations as systems of ideal elements, in their conditions as phases of a teleological existence, and in their relation to concomitant or consequent physical changes.

The writer's interest is thus not in giving a logical formulation to the conception of these phases of mental activity, nor in seeking the inner distinctions upon which their separation as ideal forms is based. He therefore systematically subordinates the guiding conceptions which may have lain back of an individual investigation and ignores the theoretical formulation to which it may have led, in order to utilize all established facts in the given field. "I have felt myself bound," Dr. Arnold says, "not to uphold any special theory or school, but to present the facts as they seem to be." With reference to all purely psychological problems the book may therefore be called selective; it represents a sifting of the literature with a view to presenting in a succinct review the ascertained facts concerning attention and interest, in their manifold connections, which are of importance to the teacher. As the writer's motive is not critical but practical, and as the aim is to make the reader acquainted with those special aspects of the subject which are of value in connection with the problems of the school-room, the discussion falls into two parts, first, the presentation of the results of experimentation, and second, the application of these results to school-room practise. The résumé of literature is given separately for each of the two topics, but the applications are considered in a single discussion. The book thus falls into three parts: (I.) Attention, (II.) Interest, (III.) Education. In dealing with each topic the writer simplifies the discussion by separating his description of the facts from their explanatory, developmental and illustrative treatments, which are considered in separate sections.

By its aim the book disarms criticism for any lack of rigid psychological criteria in the matters of definition and limitation of discussion, since it is a summary of results determined primarily by the needs of the teacher. Though the psychologist may rightly demand a definition of attention, or of interest, in such terms as to limit the view to phenomena of consciousness alone, the teacher must take into account the whole psychophysical situation in which the child is placed if he aspires to stimulate his attention or direct his interest. He must study the effects of extraneous stimulation, fatigue, nutritive condition and motor control, as well as those of practise, rest, age, mental development and the like. The mind's activities are both physically and historically conditioned, and their supplementation or ideal control is made possible by this correlation alone. From the teacher's standpoint it is just these extrinsic features of attention and interest—with which Dr. Arnold's book so largely deals—which are of real importance. The analysis of inner distinctions and correlations in the ideal systems themselves which may be called their intrinsic features are, as Herbart long ago pointed out, least of all to be considered in such a connection, though they may constitute the primary phenomenon for the introspective psychologist. Dr. Arnold's summary of these objective stimuli to interest, and of the physical conditions and manifestations of attention is full and well presented. In the opinion of the reviewer it is here that the

value of the book lies. The varied information which it brings together in a compendious form will be found useful by the psychological student and lecturer as well as by the teacher.

When the writer undertakes to bring his materials together in a systematic review the result is less satisfactory. It is, of course, impossible to keep clear of theory in any systematic presentation of fact; and while the necessity for such underlying conceptions may be masked so long as one is concerned only with reporting the results of individual experiments, the lack of guiding principles will appear whenever the attempt is made to bring together a group of particulars in a systematic review. Dr. Arnold's recapitulation of the discussion of attention, for example, suffers from the lack of a principle of division distinctly conceived and persistently adhered to. He begins this review by pointing out that "attention must be considered from two points of view," the sensory and the motor, a dualism which is expressed also in the terms "ideal" and physiological. The reader naturally assumes that this statement, with which the recapitulation begins, represents the last result of the writer's analysis, that the distinction is fundamental to the phenomena of attention. But Dr. Arnold goes on immediately to say that there are two aspects of attention, the subjective and the objective, of which the former includes both the sensory and the motor processes above mentioned. If this be so, it should be pointed out on behalf of the reader that the conditions of a good exposition surely require the more fundamental distinction to be presented first. That the latter distinction is basal appears from the following page, in which the subjective-objective is made the most general phase of the discussion.

The schema in question formulates the phenomena of attention in a way which is of permanent value, but as the grouping is not, in strictness, the order followed in the previous discussion, it can scarcely be called a recapitulation. One must drop the old subdivisions which he carried in mind throughout the reading, and substitute a new—though of course congruous—conception of relations. A question, too, may be raised concerning the propriety of the terms here employed. The aptness of the term "objective" to a summarization of the characteristics of clearness, distinctness and persistence may be granted, since these are, properly speaking, attributes of the object before consciousness; but a certain violence is done to a term already too loosely employed when accommodation and fixation, respiration and vaso-constriction, as well as fusion and free association, are made to fall within the field of the "subjective." Still more do the details of the schema reveal the need of logical formulation as well as of full citation of individual fact. The "subjective" aspect of attention, for example, is considered under the two heads, motor and sensory; but under the former appears also a subdivision entitled "motor," comprising the phenomena of innervation, diffusion and control. It is confusing, too, that under this term—which is not only popularly opposed to "sensory," but is also made its logical alternative in the present scheme—there should be made to fall the two subdivisions "sensory" and "motor" as minor terms. There is therefore the further contradiction that the term "sensory," which constitutes the basis of the second general division, should appear also as a special constituent of the first group of phenomena.

In each phase of the discussion Dr. Arnold has added to his description of the phenomena a consideration of their development in the individual mind. This is an important addition to the study which might profitably receive even more space than has been given to it. A series of illustrations is systematically appended to each chapter of the book. While these are in general well chosen, the reviewer finds some of them puzzling; but effective illustration is, after all, not only a matter of happy invention in the writer, but also one of idiosyncratic temperament in the reader, and the instances cited may nowhere present such obscurity to another mind.

Robert MacDougall

SPECIAL ARTICLES

AN INTERMITTENT SPOUTING WELL

IN parts of central Florida bored wells are somewhat extensively used for drainage purposes. The wells are drilled through the superficial material and as a rule enter the Vicksburg Limestone of Oligocene age, although other porous limestones may serve the same purpose. Many of the wells terminate in cavities in the limestone, while others reach layers of shell or other porous material. Surface water entering the wells is carried into the limestone formation. In some localities in the central part of the state these wells have been found very efficient in carrying off surface water and in draining small marsh areas for agricultural purposes.

One of these drainage wells near Orlando, in Orange County, recently developed the unusual phenomenon of spouting. The well was drilled in 1907 and is located near the edge of a small lake. It is twelve inches in diameter and has a total depth of 260 feet, and is cased 60 feet. The level of permanent underground water at this locality is 33 feet from the surface. Trucking is carried on around the edge of the lake and the well is intended, by carrying off the surplus water, to prevent the lake from rising above a given level, since to do so would flood the farming land. The well is similar in character to the other drainage wells of this locality and, as in the case of most of the other wells, terminates in a cavity in the limestone.

The well was first seen by the writer October 4, 1910. At this time the water of the lake stood a few inches above the level of the top of the pipe, and the well was receiving water at much less than its full capacity. At intervals of a few minutes the well would reverse itself and spout, throwing a column of water into the air. The spouting comes on gradually. First the well ceases to receive water and begins bubbling; the column of water follows, rising with considerable force to a height of twenty feet or more above the surface, the spout occurring with tolerable regularity at intervals of four minutes. The manager of the farm states, however, that the interval between spouts varies from two to fifteen minutes, being probably influenced by varying conditions under which the water enters the well.[1]

Although drilled three years ago and receiving water more or less continuously during that time the phenomenon of spouting developed for the first time on September 26, 1910, the first spouting having occurred about eight o'clock in the morning of that day. The well continued spouting without interruption for a little more than a week and until shut off by the owner.

Various fanciful theories have been advanced to account for the spouting, including supposed occurrence of gas and oil, and the supposed influence of recently formed sinks in the interior of the state. The true explanation is evidently much more simple. At this stage of the lake the well is receiving water at less than its full carrying capacity and as the water enters the vertical pipe it forms a suction, carrying a large amount of air into the well, which doubtless collects in a chamber or cavity along the side or at the bottom of the well. As the well continues receiving water the air accumulates under pressure in this chamber until ultimately the pressure under which the air is confined is sufficient to overcome the weight of the overlying water plus the inertia of movement, and hence rushes out with considerable force, carrying the column of water with it. The fact that the well when first drilled did not spout and afterwards began spouting doubtless indicates that the essential conditions were subsequently developed either by caving or by other changes in the underground conditions.

When partly shut off so that only a limited amount of water enters the well the air taken into the well is able to return to the surface freely and under these conditions spouting ceases. It is probable that if an elbow is placed on the well, allowing the water to enter laterally instead of vertically, the amount of air taken into the well will be so far reduced that the spouting will cease. Likewise when the lake rises so that the water stands several

[1] A photographic illustration of the spouting well will be found in the Third Annual Report of the Florida Geological Survey, pl. 9, 1910.

feet above the top of the pipe entering the well the spouting should cease, since the pipe will then be carrying water at its full capacity with little or no air under these conditions entering the well. As a matter of fact following the heavy rains attending the storm of October 17 and 18, 1910, the lake rose several feet and the well upon being reopened received water without spouting. A similar spouting well at Albany, Ga., was described some years ago by Professor S. W. McCallie.[2]

E. H. Sellards

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GRAPHITE IN VEIN QUARTZ[1]

The writer has recently discovered a graphitic quartz in Troup County, Ga., which has some geological significance, since it is entirely unlikely that the graphite is directly of organic origin. The graphite occurs in massive vein quartz and, recognizing the already known occurrence of graphite in pegmatite and gneiss at other localities, affords additional evidence of the inorganic origin of graphite under peculiar geological conditions.

The graphite occurs in small flakes and in irregular bunches, two or three millimeters in diameter or length, disseminated through massive, clear quartz. In fact, in the specimens at hand, except for iron stains, quartz and graphite are the only components of the rock. Under the microscope, minute black crystals were noted, but the black color disappeared upon ignition, leaving the crystal form intact, indicating only a covering of graphite over minute quartz crystals. The graphite, roughly estimated, forms only two or three per cent. of the quartz at present exposed.

The nearest rock exposed in the vicinity of the quartz vein is a peridotite and it is not improbable that the vein is cutting this rock. The quartz, of course, could possibly be derived from pegmatite, but at the surface neither feldspar nor mica were found with it. The vein is evidently of small dimensions. The nearest strata of certain sedimentary origin are the Pine Mountain quartzites a few miles to the southward.

Whether the quartz was deposited from an aqueous solution or is of aqueo-igneous origin, the carbon must have been held in some form in the rock solution and the graphite deposited contemporaneously with the quartz. Its dissemination, not cavity filling, through compact, crystalline quartz is sufficient evidence that it is not directly of organic origin or derived from the metamorphism of carbonaceous matter. Perhaps the most suggestive theory of the origin of the graphite under these conditions is that it was derived from carbon dioxide (CO_2), or a hydrocarbon vapor held in the siliceous solution. The presence of carbon dioxide in crystals of quartz is well known. Smoky quartz from Branchville, Conn., yielded gas, analyzed by A. W. Wright, which contained 98.33 per cent. of CO_2.

Otto Veatch

[2] Science, N. S., XXIV., p. 694, 1906.

[1] Published with the permission of the state geologist of Georgia.

CONCERNING SEXUAL COLORATION

In the linnet of California (*Carpodacus frontalis*), after the post-juvenal (first fall) molt, the sexes are conspicuously different in color. The female is obscurely streaked beneath with hair-brown on a dull white ground, above more uniformly hair-brown. The male is usually red in color, on the whole chin, throat, malar region and chest, on the frontal and lateral portions of crown, and on the rump; otherwise the male is like the female. The linnet would thus appear to provide a good case of "sexual coloration."

After the post-juvenal molt, there is, in both sexes throughout the lifetime of the individual, but one molt annually, taking place in August. *There is no pre-nuptial molt.*

In a large series of male linnets, leaving out the occasional aberrant examples which are distinctly yellow or orange, striking variation is shown in the shade and intensity of the red. Arrangement of the component examples by date, from September to July, shows this variation to parallel uniformly the lapse of time beyond the annual molt in August. In

the fresh fall plumage the red is of a dull pinkish hue (burnt carmine); there is thereafter a progressive change, slow in autumn, rapid in spring, until the breeding season finds the amorous males, bubbling with song, and going through various courting antics, arrayed in brilliant poppy red.

A nuptial attire has been donned, in the male only, but there has been no replacement of feathers; nor has there been an influx of new pigment into the feather as a former most unsound theory presupposed.

Microscopical examination of various feathers appropriately selected during the period of molt, when old and new feathers are to be found side by side, discloses the following facts: In the newly acquired, unworn plumage, the red pigment is restricted to the barbs of the contour portion of each feather, except for their terminal portions to a distance of one millimeter from their tips. These barb ends, which thus together constitute a band terminating each feather, and *all the barbules,* are white. In the extremely old, abraded (spring and autumn) feather these grayish white end portions of the barbs in the overlapping feathers, and all the barbules, have simply been broken off through attrition and lost, thus removing the grayish obscuration, and disclosing the bright red of the barbs, the tone of which has not in fact changed one whit.

Thus wear alone has accomplished the nuptial brightening of dress. A difference of structure is evident between the pigmented and unpigmented portions of the feather, the former being by far the most resistant, the latter being so adjusted in extent and texture as to become disintegrated and lost at the advent of the season of mating.

The production of color in the growing feather in August is thus clearly anticipatory; and we observe here manifestation of a most delicate structural complex, so balanced as to bring about through purely extrinsic, physical agencies, a conspicuous brightening of plumage at the season of reproduction, seven to nine months later.

The chief point to which I wish to fix attention is, that the brilliant hue of the nuptial dress is thus in reality acquired at the post-nuptial (or annual) molt, several weeks *after* the season of mating, instead of immediately preceding. This fall molt period is generally considered (as by bird fanciers and poultry raisers) to be the season of the year when the vitality of the bird is at its lowest ebb. Moreover, the organs of reproduction are at this time much reduced in size, and certainly quiescent in function. It would seem, therefore, that the production of the brilliant nuptial plumage in the linnet (and similar sequence of processes and results is well known to occur in many other passerine birds[1]) is *not* directly associated with a period of excessive sexual vigor, as a current theory postulates.

J. GRINNELL
MUSEUM OF VERTEBRATE ZOOLOGY,
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THE OKLAHOMA ACADEMY OF SCIENCE

THE academy held its second annual meeting at the State University at Norman, November 25–26. In spite of the fact that this was only its second annual meeting, about forty papers were read, among which were the following:

"The Human Tonsillar Band as a Protective Organ," Dr. J. D. McLaren.

"Study of Lipase," H. I. Jones.

"The Physical and Chemical Changes in the Burning of Clays," L. C. Snider.

"The Road Material of Oklahoma," L. C. Snider.

"The Future Sources of Power in Oklahoma," C. N. Gould.

"A Brief History of Oklahoma Geology," C. N. Gould.

"Comparison of the Four Mountain Uplifts in Oklahoma," C. N. Gould.

"The Oklahoma Redbeds," C. N. Gould.

"The Ecology of the early Juvenile Life of the Unionidæ," F. B. Isely.

"The Unionidæ of the Red River Drainage System," F. B. Isely.

"Notes of the Experimental Study of the Growth and Migration of Mussels," F. B. Isely.

[1] See, especially, Dwight, *Annals N. Y. Acad. Sci.*, Vol. XIII., 1900, pp. 73–360.

"A Method of Treating Complex Sulphides and a few of the Difficulties in Putting it into Practise," D. D. Dunkin.

"Glaciation in the Pikes Peak Quadrangle," C. H. Taylor.

"The Igneous Rocks about Cold Springs, Oklahoma," C. H. Taylor.

"The Ancestral Form of the Testudinata: An Embryological Study," H. H. Lane.

"The Stratigraphy of the Oil Region of Northeastern Oklahoma," D. W. Ohern.

"The Present Stage of the Canadian River," D. W. Ohern.

"The Study of American Government in the Public Schools," Clinton O. Bunn.

"Nationalism versus Internationalism," J. H. Sawtell.

"The Glass Sands of Oklahoma," Frank Buttram.

"Relation of Ionization to the Toxicity of Disinfectants: Preliminary Report," Oscar Harder.

"A Rapid Method of the Estimation of Salts in Butter: Preliminary Report," G. Y. Williams.

"A New Rapid Modification of the Iron-hæmatoxylin-orange G Method for Nerve Sections," A. M. Alden.

"The Application of Astronomy to Historical Research," Henry Meier.

"The Grignard Reaction," H. I. Jones.

"Building Stone Possibilities of Oklahoma," L. L. Hutchinson.

"The Available Coal of Oklahoma," L. L. Hutchinson.

"The Physical Characteristics of the Negro," Dr. A. C. Hirschfield.

"The Origin of the Concave Profile of Volcanoes," D. W. Ohern.

"The Human Heart and Dangers that Threaten it," G. T. Howerton.

"Post-mortem Findings in a Case of Pityriasis rubra pilaris," C. D. Blatchley.

The academy appointed a committee, of which Dr. C. N. Gould is chairman, to consider the advisability of securing state aid in publishing the proceedings of the academy. Another committee was appointed to institute a biological survey of the state. Of this committee Professor H. H. Lane is chairman. The academy is using all the influence that can be possibly brought to bear upon the people of the state to push forward the study of the various animal and plant forms before the influence of man disturbs natural conditions.

The next annual meeting of the academy will be held at the Central State Normal at Edmond, November 26–27, 1911.

D. W. Ohern,
Assistant Secretary

THE ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND

The fifteenth meeting of the association was held at the University of Pennsylvania, Philadelphia, on November 26, 1910. The program for the morning session was:

Address of welcome, Edgar F. Smith, vice-provost, University of Pennsylvania.

Miscellaneous business.

"Is the Average Secondary-school Pupil able to acquire a Thorough Knowledge of all the Mathematics ordinarily given in these Schools?" Isaac J. Schwatt, University of Pennsylvania. Discussion led by Rev. James J. Dean, Villanova College; Edward D. Fitch, the DeLancey School, Philadelphia, and E. B. Ziegler, Conshohocken, Pa.

Election of officers.

Following the morning session the association was entertained at luncheon by the university.

The program for the afternoon session was:

"Training for Efficiency in Elementary Mathematics," Ernest H. Kock, Jr., Pratt Institute, Brooklyn.

Report of the Committee on Mathematics in Continuation Schools, William E. Breckenridge, chairman, Stuyvesant High School, New York City.

Report of the Committee on Algebra Syllabus, Gustave Le Gras, chairman, College of the City of New York.

The officers for 1910–11 are: *President*, William Henry Metzler, Syracuse University, Syracuse, N. Y.; *Vice-president*, Philip R. Dean, Curtis High School, Staten Island, N. Y.; *Secretary*, Howard F. Hart, Montclair High School, Montclair, N. J.; *Treasurer*, Mrs. Clara H. Morris, High School for Girls, Philadelphia, Pa.; *Council Members*, Paul N. Peck, George Washington University, Washington, D. C.; Susan C. Lodge, Philadelphia Collegiate Institute, Philadelphia, Pa.; Eugene Randolph Smith, Polytechnic Preparatory School, Brooklyn, N. Y.; Isaac J. Schwatt, University of Pennsylvania, Philadelphia, Pa.; Clifford B. Upton, Teachers College, New York City; Fletcher Durrell, Lawrenceville School, Lawrenceville, N. J.

Howard F. Hart,
Secretary